Historic, archived document

Do not assume content reflects current scientific knowledge, policies, or practices.

UNITED STATES DEPARTMENT OF AGRICULTURE
BULLETIN No. 586
Contribution from the Office of Public Roads and Rural Engineering
LOGAN WALLER PAGE, Director

Washington, D. C. PROFESSIONAL PAPER February 28, 1918

PROGRESS REPORTS OF EXPERIMENTS IN DUST PREVENTION AND ROAD PRESERVATION, 1916

CONTENTS

New Experiments:

Page
- Russell Road, Alexandria County, Va. . . . 2
- Alexandria-Accotink Road, Fairfax County, Va. 15
- Gum Spring-Mt. Vernon Road, Fairfax County, Va. 20
- Texas Post Road, 1916, Corrugated Metal Culverts 27

Supplementary Reports:

- Mt. Vernon Avenue Road, Alexandria County, Va., 1915 31
- Falls Road, Montgomery County, Md., 1915 37
- Bradley Lane, Montgomery County, Md., 1915 40
- Washington, D. C., 1915 42
- Buena Vista, Fla., 1915 42
- Jupiter, Palm Beach County, Fla., 1915 42
- West Palm Beach, Fla., 1915 . . . 43

Supplementary Reports—continued

Page
- Ocala, Fla., 1915 44
- Lemon City, Fla., 1914 44
- West Palm Beach, Fla., 1914 . . . 45
- Miami, Fla., 1913 46
- Rockville Pike, Montgomery County, Md., 1913 49
- Washington, D. C., 1912 52
- Chevy Chase, Montgomery County, Md., 1912 55
- Chevy Chase, Montgomery County, Md., 1911 59
- Jamaica, N. Y., 1911 62
- Ames, Iowa, 1910 67
- Knoxville, Tenn., 1910 69
- Youngstown, Ohio, 1910 71
- Dodge City, Garden City, Bucklin, and Ford, Kans., 1908 75
- Bowling Green, Ky., 1907 76

WASHINGTON
GOVERNMENT PRINTING OFFICE
1918

UNITED STATES DEPARTMENT OF AGRICULTURE

BULLETIN No. 586

Contribution from Office of Public Roads and Rural Engineering,
LOGAN WALLER PAGE, Director.

Washington, D. C. PROFESSIONAL PAPER February 28, 1918

PROGRESS REPORTS OF EXPERIMENTS IN DUST PREVENTION AND ROAD PRESERVATION, 1916.

CONTENTS.

Page.
New Experiments........ 2
  Russell Road, Alexandria County, Va. (bituminous macadam and bituminous gravel).......... 2
  Alexandria-Accotink Road, Fairfax County, Va. (bituminous gravel, earth-oil asphalt)........ 15
  Gum Spring-Mount Vernon Road, Fairfax County, Va. (bituminous surface treatment on new gravel road)........ 20
  Texas Post Road, 1916—Corrugated Metal Culverts........ 27
Supplementary Reports on Experiments Previously Reported........ 30
  Mount Vernon Avenue Road, Alexandria County, Va., 1915 (bituminous macadam, bituminous concrete)........ 31
  Falls Road, Montgomery County, Md., 1915 (bituminous surface treatment)........ 37
  Bradley Lane, Montgomery County, Md., 1915 (bituminous macadam)........ 40
  Washington, D. C., 1915 (bituminous concrete)........ 42
  Buena Vista, Fla., 1915 (oil asphalt-coralline rock)........ 42
  Jupiter, Palm Beach County, Fla., 1915 (oil asphalt-sand)........ 42
  West Palm Beach, Fla., 1915 (bituminous sand, oil-limestone mixing methods)........ 43
  Ocala, Fla., 1915 (sand-asphalt)........ 44
  Lemon City, Fla., 1914 (oils, tar preparation, calcium chloride-coralline rock)........ 44
  West Palm Beach, Fla., 1914 (oil, tar, oil asphalt-coralline rock)........ 45
  Miami, Fla., 1913 (oil-coralline rock)........ 46
  Rockville Pike, Montgomery County, Md., 1913 (bituminous surface treatment)........ 49
  Washington, D. C., 1912 (tar preparation and oil surface treatment)........ 52
  Chevy Chase, Montgomery County, Md., 1912 (bituminous concrete, cement concrete, oil cement concrete, vitrified brick, bituminous surface treatment on concrete)........ 55
  Chevy Chase, Montgomery County, Md., 1911 (bituminous construction and surface treatment). 59
  Jamaica, N. Y., 1911 (oil cement concrete, oil asphalt, tar and fluxed native asphalt)........ 62
  Ames, Iowa, 1910 (oil asphalt gravel)........ 67
  Knoxville, Tenn., 1910 (tar and oil preparations)........ 69
  Youngstown, Ohio, 1910 (slag, lime, waste sulphite liquor, and tar)........ 71
  Dodge City, Garden City, Bucklin, and Ford, Kans., 1908 (sand-clay)........ 75
  Bowling Green, Ky., 1907 (Kentucky rock asphalt)........ 76

During the year 1916 the Office of Public Roads and Rural Engineering undertook three new experimental highway projects and a separate investigation of corrugated metal pipe for use in constructing highway culverts. All of the highway projects involved the use of bituminous materials. The principal purpose of the new road experiments has been to develop the most advantageous methods of using gravel with bituminous materials in constructing the better types of roads. Other purposes have been to investigate the value, as a road-surfacing material, of earth-oil asphalt, made by admixing asphalt with a prepared mixture of earth and water; and to secure check results with certain types of bituminous macadam that have been employed in previous experiments of the office. The culvert investigation is for the purpose of determining the relative merits of various kinds of steel and iron used in the manufacture of corrugated pipe.

Supplementary reports, describing the progress of experiments previously reported, follow the reports of the new experiments. To these supplementary reports are added, in several cases, summaries showing an outline history of the projects to date. Also, the histories of several projects that have been discontinued are summarized in this bulletin so as to make the experimental results already obtained by the office easier for the interested reader to follow.

NOTE.—In this publication "bituminous macadam by the penetration method" is called simply bituminous macadam, and "bituminous macadam by the mixing method," bituminous concrete.

NEW EXPERIMENTS.

The new experiments included bituminous macadam and bituminous gravel construction on the Russell Road in Alexandria County, Va.; bituminous gravel concrete and earth-oil asphalt on the Alexandria-Accotink Road in Fairfax County, Va.; and the bituminous surface treatment of a new gravel road leading from Gum Spring to Mount Vernon in Fairfax County, Va. In addition the special experiments with corrugated metal culverts were initiated on the Texas post road.

EXPERIMENTS ON RUSSELL ROAD, ALEXANDRIA COUNTY, VA.

BITUMINOUS MACADAM AND BITUMINOUS GRAVEL.

This experimental project is located in Alexandria County, Va. The road begins at station 0+00 or station 114+47.3 of the Mount Vernon Avenue experimental road, and runs in a general southwesterly direction on a new location to station 21+40. From there it continues in the same general direction over an old worn-out gravel road to the city line of Alexandria. The project is 8,761.4 feet in length and is divided into eight experiments, as shown in Table 1. The experiments are numbered consecutively from station 0+00 toward Alexandria. The experimental surfaces were constructed on a 6-inch pit-run gravel base throughout. Work was begun by contract July 12, 1915, and completed June 20, 1916. The total cost of the project was $22,844.94.

TABLE 1.—*Description of experiments.*

Experiment number.	Location (stations).	Stone.	Bituminous material.	
			First application.	Second application.
1[1]	1+81 to 17+81	Trap	Water-gas tar, refined	Water-gas tar, refined.
2	17+81 to 35+91	do	do	Oil asphalt.
3	35+91 to 54+55	do	Coal tar, refined	Coal tar, refined.
4	54+55 to 72+55	do	do	Oil asphalt.
5[2]	72+55 to 77+55	Gravel	Water-gas tar, refined	Water-gas tar, refined.
6	77+55 to 82+61	do	Oil asphalt	Oil asphalt.
7[3] and 8	82+61 to 87+61.4	do	Residual asphaltic petroleum.	Residual asphaltic petroleum.

---

[1] The area from station 0+00 to station 1+81 at the intersection with the Mount Vernon Avenue experimental road was surfaced with the same kind of wearing course used on experiment No. 10 of that road and is classed with that experiment.

[2] From station 72+55 to station 73+46, 30 per cent of sand was added to the tar.

[3] The gravel for this experiment was a mixture of pit-run gravel from the Haney pit with ¾-inch screened gravel imported from Richmond, Va.

GENERAL FEATURES OF THE PROJECT.

Right of way and location.—A new location was made from station 0+00 to station 21+40, in order to eliminate a railroad crossing at grade with the Washington & Old Dominion Railroad at station 12+50. The county of Alexandria secured this new right of way and and also arranged for widening the right of way of the old road to 50 feet throughout its length. The acquired right of way amounted to a total of 2.2 acres. All points of curvature and tangency of the new location lines were marked with 6-inch concrete bound stones, set with the back face center at the point.

Clearing and grubbing.—Including both old and new location, 5 acres were cleared and grubbed.

Excavation.—All excavating was done with drag and wheel scrapers and dump wagons. Wherever practicable, fills were made with wheel scrapers in uniform layers. Side-hill slopes under new fills were plowed. Slopes in cuts were finished 1:1 and on fills 1½:1. The road was graded to a width of 24 feet, the shoulders being 4 feet wide and having a slope of 1 inch to a foot. The side ditches were excavated 19 inches below the grade of the road. The crown of the subgrade was made the same as the crown of the surface ⅜ inch to a foot. Between stations 63+50 and 86+50, 469 cubic yards of earth were borrowed. This borrow was made necessary because when the estimate was prepared, too small an allowance was made for shrinkage. In all, 11,384 cubic yards of earth were excavated.

Grade crossing elimination.—An agreement was made with the Washington & Old Dominion Railroad Co. whereby the company constructed, at its own expense, abutments and a bridge span for the elimination of the grade crossing at station 12+50. By the terms of this agreement, the Department of Agriculture removed the prism of earth below the railroad and dug the foundation pits for the abutments. The excavation of the foundation pits cost $335 64. The cost to the railroad company of its portion of the work was $2,588.76.

Drainage.—Subdrainage, culverts, catch basins, and paved gutters were built where needed.

Foundation or base course.—After the grading was completed, the subgrade was brought to its final shape by the use exclusively of picks and shovels and by rolling. All spongy and yielding areas were removed and replaced with fresh material as the rolling progressed. The foundation for all the experimental sections consisted of a compacted layer of gravel 6 inches in depth. A sand-clay gravel represented by the analysis given in Table 2 obtained from Haney's pit, adjoining the road, was used. All the gravel was weighed at the pit, and sample cubic yards loose also were weighed from time to time. A total of 5,604.4 tons of gravel was placed in the foundation. The average weight of a cubic yard of loose gravel was 3,000 pounds and the expansion from the pit to the wagon was 22 per cent. The gravel was dumped on the subgrade and spread by hand to a depth of 8.7 inches. Practically all the stones of size greater than would pass a 2½-inch screen were removed in the pit or while the gravel was being spread on the road. The gravel base was rolled with a 10-ton roller and was all in place December 4, 1915. Travel was allowed over the base all winter. Before beginning the experimental surfacing, April 10, 1916, light trimming and reshaping of the base had to be done, but no serious depressions or ruts had developed.

TABLE 2.—*Mechanical analysis of gravel for use in foundation.*

	Per cent.
Passing 1-inch screen, retained on ¾-inch screen	1.4
Passing ¾-inch screen, retained on ½-inch screen	15.7
Passing ½-inch screen, retained on ¼-inch screen	25.7
Passing ¼-inch screen, retained on 10-mesh sieve	19.6
Passing 10-mesh sieve, retained on 20-mesh sieve	10.1
Passing 20-mesh sieve, retained on 30-mesh sieve	5.1
Passing 30-mesh sieve, retained on 40-mesh sieve	3.2
Passing 40-mesh sieve, retained on 50-mesh sieve	3.8
Passing 50-mesh sieve, retained on 80-mesh sieve	3.2
Passing 80-mesh sieve, retained on 100-mesh sieve	.8
Passing 100-mesh sieve, retained on 200-mesh sieve	2.4
Passing 200-mesh sieve	9.0
Total	100.0

Shoulders.—Earth shoulders were constructed 4 feet wide, with a slope of 1 inch to the foot. They were rolled and trimmed as the surface was completed.

Guard-rails.—Wooden guard-rails were constructed along the road 3 feet outside the edge of the bituminous surface at the stations shown in Table 3.

TABLE 3.—*Location of guard-rails.*

Left.	Right.
Station 1+82 to Station 4+79	Station 1+41 to Station 4+66
Station 14+71 to Station 16+60	Station 22+59 to Station 24+75
Station 20+00 to Station 25+78	Station 24+88 to Station 26+00
Station 40+40 to Station 42+26	Station 40+10 to Station 43+76
Station 56+90 to Station 57+94	Station 55+06 to Station 59+06
Station 58+24 to Station 59+68	Station 63+25 to Station 63+65
Station 63+00 to Station 64+00	Station 67+38 to Station 72+34
Station 66+41 to Station 72+60	Station 77+84 to Station 79+28
Station 77+63 to Station 79+63	

Total, 4,519 linear feet.

TESTS OF MATERIALS.

TABLE 4.—*Physical properties of trap rock used in the surface construction.*

Specific gravity		3.00
Weight per cubic foot	pounds	187
Water absorbed per cubic foot	do	.43
Per cent of wear		2.6
French coefficient of wear		15.5
Hardness		18.3
Toughness		13
Cementing value		Fair.

TABLE 5.—*Mechanical analysis of gravel and sand used in the surface construction.*

	Screened gravel for use in penetration experiments Nos. 5 and 6.	Clean sand for experiments Nos. 5 and 8.	Sand-clay gravel for experiments Nos. 7 and 8.	Pea-gravel for gravel experiments Nos. 5, 6, 7 and 8.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*
Retained on 2 inch screen	37.3			
Passing 2-inch, retained on 1½-inch screen	21.2			
Passing 1½-inch, retained on 1¼-inch screen	29.5		4.7	
Passing 1¼-inch, retained on 1-inch screen	10.5		0.4	
Passing 1-inch, retained on ¾-inch screen	1.5		4.0	
Passing ¾-inch, retained on ½-inch screen			14.9	9.9
Passing ½-inch, retained on ¼-inch screen			23.6	50.4
Passing ¼-inch, retained on 10-mesh sieve			16.8	34.2
Passing 10-mesh sieve retained on 20-mesh sieve		7.2	6.1	5.5
Passing 20-mesh sieve retained on 30-inch sieve		19.6	3.7	
Passing 30-mesh sieve retained on 40-mesh sieve		25.6	3.1	
Passing 40-mesh sieve retained on 50-mesh sieve		22.4	2.5	
Passing 50-mesh sieve retained on 80-mesh sieve		17.2	2.6	
Passing 80-mesh sieve retained on 100-mesh sieve		1.6	.5	
Passing 100-mesh sieve retained on 200-mesh sieve		5.0	2.0	
Passing 200-mesh sieve		1.4	15.1	
Total	100.0	100.0	100.0	100.0

TABLE 6.—*Mechanical analysis of trap rock used in surface construction of experiments 1, 2, 3, and 4.*

	Trap rock for penetration.	Trap-rock chips.
	Per cent.	*Per cent.*
Retained 2-inch screen	20.6	....
Passing 2-inch, retained on 1½-inch screen	37.5	....
Passing 1½-inch, retained on 1¼-inch screen	17.0	....
Passing 1¼-inch, retained on 1-inch screen	12.4	....
Passing 1-inch, retained on ¾-inch screen	9.1	15.0
Passing ¾-inch, retained on ½-inch screen	2.4	36.0
Passing ½-inch, retained on ¼-inch screen	.9	37.0
Passing ¼-inch, retained on 10-mesh sieve	[1].1	11.3
Passing 10-mesh sieve	....	.7
Total	100.0	100.0

[1] Passing ¼-inch screen.

TABLE 7.—*Analysis of refined tars.*

	Coal tar, refined.	Water-gas tar, refined.
	Experiments Nos. 3 and 4.	Experiments Nos. 1, 2, and 5.
Specific gravity 25°C/25°C	1.206	1.150
Float test 50°C	2′38″	2′34″
Soluble in CS_2 (total bitumen)..per cent..	84.99	98.28
Free carbon ....do....	14.96	1.65
Inorganic residue upon ignition.....do....	.05	.07

Distillation.	Character.	Per cent by volume.	Per cent by weight.	Character.	Per cent by volume.	Per cent by weight.
Water	Trace.	0.0	0.0	Trace.	0.0	0.0
First light oils (to 110°C)	......do...	.0	.0	......do...	.0	.0
Second light oils (110° to 170°C)	Cloudy.	.2	.1	......do...	.0	.0
Heavy oils (170° to 270°C)	......do...	10.2	7.9	Cloudy.	19.0	16.5
Heavy oils (270° to 300°C)	......do...	10.0	8.1	......do...	12.4	10.2
Pitch	....	79.6	83.8	....	68.6	73.3
		100.0	100.0		100.0	100.0

TABLE 8.—*Analyses of petroleum products.*

	Oil asphalts.		Residual asphaltic petroleum.
	Experiment No. 6.	Experiment Nos. 2 and 4.	Experiment Nos. 7 and 8.
Specific gravity 25°/25°C	1.040	1.053	0.993
Melting point, °C	49	58	....
Float test at 50°C (time)	....	....	0′28″
Specific viscosity Engler 100°C., 50cc	....	....	14.9
Penetration at 25°C., 100 grams, 5 sec	98	58	....
Loss, 5 hrs., 163°C., 20 grams, ...per cent..	3.01	....	13.98
Penetration of residue, as above	58	37	....
Per cent of total bitumen insoluble in 86°B naphtha	27.70	30.05	18.88
Fixed carbon ....per cent..	17.25	18.85	9.96
Soluble in CS_2 (total bitumen) ....do....	99.80	99.80	99.93
Organic matter insoluble ....do....	.09	.17	.07
Inorganic matter insoluble ....do....	.11	.03	.00
	100.00	100.00	100.00

DESCRIPTION OF EXPERIMENTS.

EXPERIMENT No. 1.—BITUMINOUS MACADAM: TRAP ROCK WITH REFINED WATER-GAS TAR.

Location, station 1+81 to station 17+81.
Total length, 1,600 feet.
Total area, 2844.4 square yards.

The gravel base, as mentioned, had been under traffic for 4 months before the experimental surface was begun. The base was in good condition and required only a small amount of trimming and reshaping. One and one-half inch trap rock, having the physical properties and the mechanical analysis shown in Tables 4 and 6, was hauled in dump wagons and spread by hand to a depth of 3 inches. The spread stone was rolled until well keyed for two or three stations in advance of the pouring of the bituminous material which was heated in 500-gallon kettles mounted on trucks. The tar, at a temperature of 250° to 300° F., was drawn off into 4-gallon hand-pouring pots and applied at the rate of 1½ gallons to the square yard. The distribution was controlled by pouring in longitudinal strips with as little lapping as possible.

Clean stone chips were spread on the surface while the bituminous material was still hot and were broomed to an even distribution while the surface was being rolled with a 10-ton macadam roller. A seal coat of the hot tar, slightly in excess of one-half gallon per square yard, was applied. Chips then were spread in such quantity as to cover all visible bituminous material and rolled immediately. The mechanical analysis of the chips is shown in Table 6.

EXPERIMENT No. 2—BITUMINOUS MACADAM: TRAP ROCK WITH REFINED WATER-GAS TAR AS BINDER AND OIL ASPHALT FOR THE SEAL COAT.

Location, station 17+81 to station 35+91.
Total length, 1,810 feet.
Total area, 3,217.7 square yards.

The construction of this experiment was exactly as described for experiment No. 1, except that an oil asphalt at a temperature of 275° to 350° F. was used as the seal coat and applied in the same quantity and manner as the tar seal coat in experiment No. 1.

EXPERIMENT No. 3: BITUMINOUS MACADAM: TRAP ROCK WITH REFINED COAL TAR FOR BINDER AND SEAL COAT.

Location, station 35+91 to station 54+55.
Total length, 1,864 feet.
Total area, 3,313.7 square yards.

This experiment differs from experiments 1 and 2 only in the bituminous material.

EXPERIMENT No. 4.—BITUMINOUS MACADAM: TRAP WITH REFINED COAL TAR BINDER AND OIL ASPHALT SEAL COAT.

Location, station 54+55 to station 72+55.
Total length, 1,800 feet.
Total area, 3,311.1 square yards.[1]

This experiment differs from No. 2 only in the kind of tar used for the penetration course.

EXPERIMENT No. 5.—BITUMINOUS GRAVEL MACADAM, GRAVEL BEING GROUTED WITH MIXTURE OF SAND AND REFINED WATER-GAS TAR.

Location, station 72+55 to station 77+55.
Total length, 500 feet.
Total area, 888.8 square yards.

The gravel used in this experiment was received from Richmond, Va., and had been washed and screened. The mechanical analysis is shown in Table 5. The gravel was spread 3 inches thick, loose, and was rolled with a 10-ton roller. The fragments cracked slightly, and the surface tended to become wavy under the roller. After rolling the gravel, a grout of sand and refined water-gas tar was applied for the first 91 feet. The grout was mixed in the heating kettle in the proportion of about 3 parts of sand by volume to 5 parts of tar. The sand was not dry and considerable foaming in the kettle resulted. In mixing the materials it was found impossible to prevent the sand from settling to the bottom of the kettle, regardless of the care used in stirring, so that this method was abandoned. It had been expected to apply 1½ gallons of this mixture to the square yard. The section was covered with pea gravel, rolled, and a seal coat applied later, as described below. The remainder of the experiment was constructed as follows: A penetration coat of refined water-gas tar was applied as in experiment No. 1, and sand, as shown in the mechanical analysis of Table 5 was applied by shovels to the surface until all voids were filled. The surplus sand was swept off and areas showing voids were filled carefully. A seal coat of refined water-gas tar and pea gravel to the amount of 0.6 gallon of tar and about 0.02 cubic yard of pea gravel per square yard then was applied to the entire section. A final rolling with the 10-ton roller completed the section.

EXPERIMENT No. 6.—BITUMINOUS GRAVEL (PENETRATION METHOD). OIL ASPHALT FOR PENETRATION AND SEAL COAT.

Location, station 77+55 to station 82+61.
Total length, 506 feet.
Total area, 899.5 square yards.

Experiment No. 6 was built according to the same method employed in experiments Nos. 1 to 4, except that an asphaltic oil was used instead of tar for both the penetration and the seal coat, and clean screened gravel and pea gravel were substituted for the trap rock. The mechanical analyses of the gravels are shown in Table 5.

---

[1] Includes 111.1 square yards widening on curve.

EXPERIMENT NO. 7.—GRAVEL CONSTRUCTION, WITH SURFACE TREATMENT OF RESIDUAL ASPHALTIC PETROLEUM.

Location, station 82+61 to station 85+61.
Total length, 300 feet.
Total area, 533.3 square yards.

In this experiment the surfacing was constructed of a 4-inch layer of pit-run gravel, upon which was placed a 1-inch layer of clean, washed gravel. The entire course was harrowed with a spike-tooth harrow, sprinkled thoroughly and rolled, after which the entire experiment was opened to traffic for one month. The surface, which then had become thoroughly compacted, was roughened with picks and harrowed loose to an average depth of 1 inch. The bituminous treatment followed immediately after the harrowing, and consisted of (1) an application of 0.68 gallon of hot residual asphaltic petroleum per square yard, covered with pea gravel, and rolled; and (2) an application of 0.55 gallon of the same oil per square yard, covered with sand, and rolled. After the surface had been finished for a day or two there was a tendency toward bleeding, and more sand was applied.

Experiment No. 8 was planned originally as a part of experiment No. 7, and no distinction was made between them in the records and cost data. Therefore they are considered together in other parts of this report.

EXPERIMENT NO. 8.—(ORIGINALLY A PART OF EXPERIMENT NO. 7.)—GRAVEL CONSTRUCTION WITH SURFACE TREATMENT OF RESIDUAL ASPHALTIC PETROLEUM.

Location, station 85+61 to station 87+61.
Total length, 200 feet.
Total area, 355.5 square yards.

This experiment was similar in all respects to experiment No. 7, except as follows: The surface treatment consisted of a single application of hot residual asphaltic petroleum, at the rate of 0.693 gallon per square yard, with a covering of pea gravel. A thin coat of dry sand-clay, of very homogeneous quality was applied over the surface treatment without any additional oil, and rolling completed the experiment.

SUMMARY OF COST DATA FOR ENTIRE PROJECT.

The cost data for the experiments described above are presented in Tables 9 to 16.

TABLE 9.—*Cost data for grading and subgrade.*

Items.	Clearing and grubbing.	Excavation.	Shaping.	Rolling.[1]	Subgrade, complete (total).
	Acres.	*Cubic yards.*	*Sq. yds.*	*Sq. yds.*	*Sq. yds.*
Quantity	5.0	11,383.9	23,423.9	15,627.5	15,627.5
Labor	$189.49	$4,227.24	$1,448.62	$34.65	$5,900.00
Materials	....	....	....	[2] 11.50	11.50
Total cost	189.49	4,227.24	1,448.62	46.15	5,911.50
Unit cost	37.89	.371	.6618	.003	.38

[1] Includes 7,796.4 square yards shoulders.

[2] Coal oil, etc.

TABLE 10.—*Cost data for drainage structures.*

Items.	Concrete culvert.	Pipe culvert.	French subdrain.	Cobble subdrain.	Open drain.	Concrete gutter.	Cobble gutter.	Cobble basins.	Drive drain.	Brick head walls.	Drainage system (total).
	Cu. yds.	*Lin. ft.*	*Lin. ft.*	*Lin. ft.*	*Lin. ft.*	*Cu. yds.*	*Sq. yds.*	*No.*	*Lin. ft.*	*Cu. yds.*	
Quantity	[1] 35.83	[2] 323	420	200	100	33.96	66	2	146	15.87	....
Labor	$221.55	$177.57	$219.79	$25.62	$66.28	$149.00	$89.48	$75.16	$50.15	$220.08	$1,294.68
Material	[3] 150.00	[4] 292.29	71.09	....	....	[3] 100.00	3.12	5.80	(5)	135.60	724.62
Total	371.55	469.86	290.88	25.62	66.28	249.00	92.60	80.96	50.15	355.68	2,052.58
Unit cost	10.37	1.45	.69	.128	.663	7.30	1.40	40.48	.343	22.41	....

[1] Includes retaining wall of 5.63 cubic yards of concrete.

[2] Includes 103 feet of vitrified pipe repaired and relaid, labor on the same $29.12, included above.

[3] Estimated.

[4] Of this amount $137.95 was for material bought and not used on Mount Vernon Avenue, and $10.44 for separate lengths of vitrified clay pipe.

[5] Furnished by the county.

TABLE 11.—*Cost data for incidentals.*

Items.	Superintendence.	Equipment.	Extra work.	Guard rail.[1]	Waste bitumen.[2]	Bound stones.	Miscellaneous.	W. & O. D. pass.	Total.
Labor	$290.10	....	$172.09	$262.06	....	$18.53	[3] $8.00	$335.64	$1,086.42
Materials	....	....	8.75	543.29	$266.08	6.56	....	....	824.68
Rent and insurance	500.00	[4] $670.00	....	....	....	....	....	....	1,170.00
Total	790.10	670.00	180.84	805.35	266.08	25.09	8.00	335.64	3,081.10

[1] 4,519 linear feet at 17.7 cents each.

[2] Includes 20 barrels left on road, lost by overturned barrels burned, and material adhering to staves (estimated 1 per cent) and used to dip posts.

[3] Storing extra posts.

[4] Includes rent of roller, $30, also depreciation on roller, heating kettles, and small tools.

TABLE 12.—*Cost data for foundation course.*

Items.	Gravel in pit.	Loosening and loading.	Hauling.	Spreading.	Rolling.	Foundation complete (total).
	Tons.	*Tons.*	*Tons.*	*Sq. yds.*	*Sq. yds.*	*Sq. yds.*
Quantity	5,604.4	5,604.4	5,604.4	15,487.7	15,487.7	15,487.7
Labor	....	$528.58	$1,453.30	$470.84	$47.74	$2,500.46
Materials	$324.10	45.00	....	....	15.49	384.59
Total	324.10	573.58	1,453.30	470.84	63.23	2,885.05
Cost per square yard	.0209	.0370	.0938	.0304	.00408	.1863

TABLE 13.—*Cost data for surfacing.*

Item.	Stone on work.	Spreading stone.	Bitumen on work.	Application of bitumen.	Rolling.	Surface complete.
	Tons.	*Tons.*	*Gals.*	*Sq. yds.*	*Sq. yds.*	*Sq. yds.*
Quantity	2,177.39	2,177.39	31,197.17	15,287.7	15,287.7	15,287.7
Labor	$1,065.10	$215.81	$100.74	$259.13	$47.57	$1,688.35
Materials	2,833.67		2,543.17		18.11	5,394.95
Total	3,898.77	215.81	2,643.91	259.13	65.68	7,083.30
Unit cost	$1.790	$0.099	$0.0847	$0.017	$0.0043	$0.463

TABLE 14.—*Total costs.*

Item.	Quantity.	Cost.	Unit cost.	Per cent of total.
	Sq. yds.			
Subgrade	15,627.5	$5,911.50	$0.38	28.1
Drainage		2,052.58		9.8
Gravel foundation	15,487.6	2,885.05	.19	13.7
Surfacing	15,287.7	7,083.30	.46	33.7
Incidentals		3,081.10		14.7
Total		21,013.53		100

TABLE 15.—*Total materials and cost data per square yard for the different experiments.*

Experiment No.	Location.	Description.					Quantity of material.		
		Stone.	Bitumen.		Length of section.	Area of section.	Gravel or stone.	Pea gravel or stone chips.	Bituminous material.
			First application.	Second application.					
					Feet.	*Sq. yds.*	*Tons.*	*Tons.*	*Gallons.*
1	Station 1+81 to Station 17+81	Trap rock	W. G. tar ref	W. G. tar ref	1,600	2,844.40	324.23	70.07	6,243.25
2	Station 17+81 to Station 35+91	Trap rock	W. G. tar ref	Oil asphalt	1,810	3,217.78	336.96	79.30	Pen. 5,238.55 Seal 1,991.0
3	Station 35+91 to Station 54+55	Trap rock	C. T. ref	C. T. ref	1,864	3,313.78	337.86	81.66	Pen 6,477.4 Seal 4,518.3
4	Station 54+55 to Station 72+55	Trap	C. T. ref	Oil asphalt	1,800	3,234.58	364.95	78.87	2,016.00
5	Station 72+55 to Station 77+55	Washed gravel	W. G. tar ref.[1]	W. G. tar ref	500	888.89	93.93	46.00	1,842.75
6	Station 77+55 to Station 82+61	Washed gravel	Oil asphalt	Oil asphalt	506	899.33	93.93	25.89	1,965.43
7 and 8	Station 82+61 to Station 87+61	Pit gravel	Res. asph. pet	Res. asph. pet	500	888.89	210.00	33.75	904.50

[1] For the first 91 feet 30 per cent of sand was added to the tar.

COST PER SQUARE YARD (CENTS).

Experiment No.	Stone on siding.	Unloading stone.	Hauling stone.	Spreading stone.	Chips on siding.	Unloading chips.	Hauling chips.	Spreading chips.	Bitumen on siding	Hauling bitumen.	Loading and heating bitumen.	Applying bitumen.	Rolling penetration stone.	Rolling penetration and seal coat.	Total cost.
1	15.955	2.645	1.122	0.916	4.064	0.728	0.310	0.419	17.67	0.659	0.664	1.035	0.324	0.089	46.605
2	15.965	2.646	2.249	.913	4.066	.730	.620	.420	18.20	.660	.664	1.035	.325	.089	48.594
3	15.963	2.647	3.373	.913	4.066	.730	.930	.419	15.72	.638	.664	.999	.314	.089	47.551
4	15.795	2.618	4.055	.904	4.023	.722	1.118	.415	16.40	.654	.657	1.023	.322	.088	48.782
5	11.740	.416	3.763	.695	1.616	.337	1.710	.349	16.68	.660	.665	1.035	.472	.061	40.209
6	11.604	.400	3.719	.743	3.199	.183	.958	.289	18.60	.660	.662	1.032	.467	.073	42.580
7 and 8	4.137	2.733	5.955	3.085	2.936	.674	1.393	.251	9.88	.660	.665	1.035	.306	.141	33.745

TABLE 16.—*Total costs.*

Experiment No.	Stone on siding.	Unloading stone.	Hauling stone.	Spreading stone.	Chips on siding.	Unloading chips.	Hauling chips.	Spreading chips.
1	$453.92	$75.25	$31.94	$25.96	$115.61	$20.75	$8.81	$11.92
2	513.75	85.18	72.36	29.39	130.85	23.48	19.95	13.50
3	529.00	87.72	111.78	30.26	134.74	24.18	30.81	13.90
4	510.93	84.72	131.15	29.23	130.14	23.35	36.16	13.42
5	104.36	3.70	33.45	6.18	14.37	3.00	15.20	3.10
6	104.36	3.70	33.45	6.68	28.77	1.65	8.62	2.60
7 and 8	36.77	24.30	52.94	27.43	[1] 26.10	[1] 6.00	[1] 11.50	[1] 2.24
Total	2,253.09	364.57	467.07	155.13	580.58	102.41	131.05	60.68

[1] Add sand.

Experiment No.	Bitumen on siding.	Hauling bitumen.	Loading and heating.	Applying bitumen.	Rolling		Total.
					Penetration stone.	Penetration and seal coat.	
1	$502.58	$18.79	$18.90	$29.45	$9.24	$2.54	$1,325.66
2	585.96	21.25	21.36	33.31	10.46	2.88	1,563.68
3	521.44	21.89	22.01	34.28	10.76	2.97	1,575.74
4	530.05	21.14	21.25	33.10	10.40	2.86	1,577.90
5	148.34	5.87	5.91	9.20	4.20	.54	357.42
6	167.07	5.93	5.96	9.29	4.20	.66	382.94
7 and 8	87.73	5.87	5.91	9.20	2.72	1.25	299.96
Total	2,543.17	100.74	101.30	157.83	51.98	13.70	7,083.30

PRICES OF LABOR AND MATERIALS.

The above cost data are based upon the following unit costs for labor and materials (f. o. b. nearest siding):

Common labor, per day, $1.50 to $1.75.
Skilled labor, per day, $1.75 to $2.25.
Teams, per day, $4.00 to $4.50.
Foreman, per day, $2.25 to $4.00.
Carpenters, per day, $2.50 to $5.00.
Roller man, per month, $65.00 to $70.00.
Superintendent, per month, $125.00.
Trap rock, f. o. b. siding:
  1½ inch, per ton, $1.40.
  Chips, per ton, $1.65.
Gravel, pit-run, per ton, $0.067.
Gravel, pea, per cubic yard, $1.50.
Tar, per gallon, $0.0805.
Oil asphalt exp. Nos. 2 and 4, per gallon, $0.0825.
Residual asphaltic petroleum, per gallon, $0.097.
Oil asphalt exp. No. 6, per gallon, $0.085.
Cement, per barrel, $1.65.
Washed gravel (concrete), per ton, $0.75.
Sand, per ton, $0.55.
Lumber, per M, $25.00.
Reinforcing steel, per pound, $0.03.
Coal, per ton, delivered, $4.00 to $5.00.
Cast iron pipe, 16-inch, per foot, $1.35.
Corrugated metal pipe:
  15-inch, per foot, $0.67.
  18-inch, per foot, $0.783.

Additional items of depreciation, repair, interest and rental on equipment, etc.:

Penetration equipment, $300.00.
Roller, $250.00.
Wagons, $50.00.
Plows, small tools, $70.00.
Bond, insurance, superintendence, transportation and travel, general office, $790.00.

TABLE 17.—*Volume and character of traffic on Russell Road.*

[This table gives the results of traffic counts taken before and after improvement of the road.

		Average before improvement.[1]		Average after improvement.[2]			
				Maximum.		Average.	
		North-bound.	South-bound.	North-bound.	South-bound.	North-bound.	South-bound.
1	Loaded 1-horse wagon	8	9	1	2	....	1
2	Unloaded 1-horse wagon	1	0	3	2	1	1
3	Loaded 2-horse wagon	3	4	1	2	....	....
4	Unloaded 2-horse wagon	1	1	3	1	....	....
5	Loaded 4-horse wagon	0	0	0	1	....	....
6	Unloaded 4-horse wagon	1	0	8	8	1	1
7	One-horse pleasure vehicle	10	10	2	1	....	....
8	Two-horse pleasure vehicle	2	2	1	1	....	....
9	Rubber-tired horse vehicle	0	0	1	1	....	....
10	Saddle horse	2	0	96	1	1	....
11	Motor cycle	6	6	8	8	1	3
12	Excessively heavy vehicle	0	0	....	....	....	....
13	Motor runabout	0	0	72	75	11	10
14	Motor touring car	55	52	271	266	107	107
15	Loaded motor dray	2	2	2	6	2	3
16	Unloaded motor dray	1	1	6	7	2	2

[1] Average of seven days in June, 1915.

[2] August 3 to December 24, 1916.

SUMMARY OF EXPERIMENTS ON THE RUSSELL ROAD.

The following report describes the condition of the experiments when inspected on January 11, 1917.

Experiment No. 1.—Bituminous Macadam, Refined Water-gas Tar.

The surface of this experiment is true and regular, but has a very rough appearance, due to the wearing away of the seal coat. It has raveled slightly in a few places, but is in excellent condition for the application of another seal coat and should have it at the earliest possible date.

Experiment No. 2.—Bituminous Macadam, Refined Water-gas Tar, Oil Asphalt Seal Coat.

This is in practically perfect condition and shows no tendency to ravel or disintegrate. The surface is much smoother than that of No. 1, and offers an interesting comparison between the relative wear of tar and asphalt for a seal coat material.

Experiment No. 3.—Bituminous Macadam, Refined Coal Tar.

The general appearance of this surface is between that of experiments Nos. 1 and 2. It shows some tendency to ravel and needs a medium heavy seal coat.

Experiment No. 4.—Bituminous Macadam, Refined Coal-tar, Oil Asphalt Seal Coat.

This surface appeared to be intact and satisfactory in every respect at the time of inspection, and was appreciably smoother than that of No. 3.

EXPERIMENT NO. 5.—BITUMINOUS GRAVEL MACADAM, REFINED WATER-GAS TAR.
EXPERIMENT NO. 6.—BITUMINOUS GRAVEL MACADAM, OIL-ASPHALT.

There is practically no difference between the two sections at this time, nor is there any evidence of the point where the use of grout was discontinued after a short section had been laid. The surfaces are in excellent condition and show the aggregate throughout, but there is no raveling or displacement.

EXPERIMENT NO. 7.—GRAVEL, SURFACE TREATED WITH RESIDUAL ASPHALTIC PETROLEUM.

This experiment had a double application. It is rather badly waved from the edges to the quarter points and shows a tendency to form broad, shallow depressions in the wheel tracks. The mat, however, is practically intact and uniform, and except for the waviness along the sides, may be considered in satisfactory condition.

EXPERIMENT NO. 8.—GRAVEL, SURFACE TREATED WITH RESIDUAL ASPHALTIC PETROLEUM.

This experiment had only one application. It has a few waves, and inequalities of application have left long lean streaks in the surface. At one point slight raveling has started along one of these streaks and the mat is irregular, and, where lean, shows a marked tendency to crumble.

Such expenses as have been incurred for the maintenance of this road will be carried forward and reported in the next progress report.

EXPERIMENTS ON THE ALEXANDRIA-ACCOTINK ROAD, FAIRFAX COUNTY, VA.

BITUMINOUS GRAVEL CONCRETE AND EARTH OIL-ASPHALT.

This experimental project is located on the Alexandria-Accotink Road, in Fairfax County, Va. It begins at the south end of Hunting Creek Bridge, the corporate limits of the city of Alexandria, and runs in a southerly direction to Gum Spring. The road was improved originally during 1914–15 under the post-road act of August, 1912. It was surfaced to a width of 14 feet with gravel, the compacted depth of which was 7 inches. The maximum grade was 7 per cent.

The old gravel road was reshaped, given a crown of one-fourth inch to 1 foot, and covered with an experimental surfacing. The total length of the road was 25,100 feet. The width surfaced was 14 feet, except at some sharp curves and road intersections, where it was widened. Gravel shoulders were constructed on either side of the finished surface. These were made 4 feet wide in fills and 3 feet in cuts. The thickness of gravel at the edge of the surface was 4 inches.

In addition to the surfacing and shoulders some extra work was done. Guardrail was built from station 57+50 to station 62+00, station 198+00 to station 204+00, and station 248+00 to station 250+00. Several pipe culverts were lengthened and new headwalls built. A new 4 by 4 by 33 foot concrete box culvert was built at station 133+55.

BITUMINOUS GRAVEL CONCRETE.

Location, station 0+00 to station 217+00.
station 223+00 to station 250+80.
Total length, 24,500 feet.
Total area, 38,442.6 square yards.

The materials for this experiment were:

Asphalt.—Oil asphalt; see typical analysis in Table 18.

Aggregate.—Crushed and screened gravel from the Ayers pit. Fine aggregate passing ¼-inch circular openings, coarse aggregate passing 1¼-inch and retained on ¼-inch circular openings. Fine aggregate contained less than 5 per cent of clay.

Limestone dust.—Ordinary ground limestone used as filler.

Pea gravel.—Washed Potomac River gravel, screened through ½-inch and over ¼-inch screen. Used as top-dressing for seal coat.

The mixing plant was of the stationary type, operated by steam power. The gravel was excavated by hand, run through a jaw crusher, and screened to remove tailings before it was heated. The heating was done in two rotary drums, wood being used as fuel. The fine and coarse aggregates then were separated by means of a ¼-inch screen and stored in two bins immediately over the mixer. The asphalt was heated in two kettles supplied with steam coils, and the mixing was done in an ordinary twin pug mixer. The average time for mixing a batch was 1 minute. Table 19 shows analyses of several samples of mix taken at the plant. Table 20 shows similar analyses of road samples of mix.

Most of the hauling was done with 1-ton autotrucks, which carried three batches of the hot mix at a load. On the longest haul distances several two-horse wagons carrying four batches to a load were used to supplement the trucks.

The hot mix was dumped from the trucks or wagons onto a steel dumping board and spread with hand shovels and asphalt rakes. Then it was "set" by rolling with a 2½-ton tandem roller and compacted to its final shape with an 8-ton tandem roller. The loose depth of the hot mix averaged about 2¾ inches, and the compacted depth was not less than 2 inches. The temperature at which the material was spread ranged from 200° to 300° F.

The seal coat was of the same asphalt used in the mix, covered with pea gravel. The asphalt was spread at a temperature of about 350° F., about one-third gallon per square yard being used. The pea gravel was spread at the rate of about 1 cubic yard to 150 square yards of surface. After the gravel was spread the surface was rolled with the 8-ton tandem roller.

EARTH-OIL ASPHALT EXPERIMENT.

Location, station 217+00 to station 223+00.
Total length, 600 feet.
Total area, 934.8 square yards.

The experiment was based upon laboratory investigations which in May resulted in the construction of a 50-foot section of earth-asphalt on the Arlington Farm of the Department of Agriculture. The section selected was a part of an earth road, the soil of which was largely fine clay. About 2 inches of this material was removed from the surface and the section was brought to a uniform grade and cross-section and rolled with a 2-ton tandem roller. The excavated material was hauled to a local paving plant, mixed with water and hot oil asphalt to form a mixture of proper consistency, which was deposited in a layer about 3 inches thick on the earth subgrade above described. The mixture in this case was too stiff to be handled satisfactorily with rakes and too soft to be rolled. It was shaped in the best manner possible with shovel backs and allowed to dry out. The surface hardened rapidly, with the formation of numerous contraction cracks. These were filled with a thin grout of the same mixture used in the surface, and the section was opened to traffic. It remained in excellent condition throughout the summer and autumn, although the contiguous earth road was almost impassable at times in wet weather. At about the time freezing weather set in traffic was cut off the section in order to make some drain connections. It soon was observed that the soil-asphalt surface began to crack, owing probably to the effect of frost action on the underlying subgrade, and in a short time complete disintegration extended from the sides toward the center.

The materials used in the longer experiment about to be described were a very homogeneous clay soil, asphalt, and water. The properties of the soil and asphalt are shown in Tables 21 and 18, respectively.

The mixing was done at the same plant used for mixing the bituminous gravel concrete, but in an entirely different manner. The soil was measured first into the mixer just as it came from the bank. Water was admixed to form a rather sloppy mud, after which the hot asphalt was added and the mixing was continued until a uniform gray color was produced. The temperature of the asphalt was about 250° F., but the temperature of the fresh mixture was only slightly higher than that of the air. The proportions of the mixture were such that each batch contained approximately 560 pounds of earth, 100 pounds of asphalt, and 25 to 30 gallons of water. Results of analyses of the mixture show an actual percentage of asphalt of 14.68.

TABLE 18.—*Analyses of asphalts.*

	Experiment.	
	Bituminous gravel concrete.	Clay asphalt.
Specific gravity 25°/25° C.	1.041	1.035
Melting point °C.	54.5	55
Penetration at 25° C., 100 grams, 5 sec.	64	101
Loss, 5 hours, 163° C., 20 grams ... per cent.	.28	.42
Penetration of residue, as above	42	57
Per cent of total bitumen insoluble in 86° B naphtha	29.48	27.09
Fixed carbon ... per cent.	18.88	17.03
Soluble in CS_2 (total bitumen) ... do.	99.45	99.86
Organic matter, insoluble ... do.	.16	.10
Inorganic matter, insoluble ... do.	.39	.04
Total ... do.	100.00	100.00

TABLE 19.—*Tests of bituminous concrete (plant samples).*

	Sample having maximum bitumen.	Sample having minimum bitumen.	Sample having maximum coarse aggregate.	Sample having minimum coarse aggregate.	Average of 61 samples.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Bitumen	8.5	5.2	5.4	7.0	6.5
Aggregate retained on ¼-inch screen	48.4	59.0	68.3	34.1	54.5
Passing ¼ inch screen and retained on 200-mesh sieve	38.5	34.3	23.3	55.2	35.8
Passing 200-mesh sieve	4.6	1.5	3.0	3.7	3.2
Total	100.0	100.0	100.0	100.0	100.0

TABLE 20.—*Tests of bituminous concrete (road samples).*

	Sample having maximum bitumen.	Sample having minimum bitumen.	Sample having maximum coarse aggregate.	Sample having minimum coarse aggregate.	Average of 42 samples.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Bitumen	8.8	4.0	5.1	8.5	6.4
Aggregate retained on ¼-inch screen	52.9	62.8	66.8	46.5	54.5
Passing ¼-inch screen and retained on 200-mesh sieve	35.8	31.3	25.7	41.6	36.1
Passing 200-mesh sieve	2.5	1.9	2.4	3.4	3.0
Total	100.0	100.0	100.0	100.0	100.0

TABLE 21.—*Mechanical analysis of earth.*

	Per cent.
Passing ¼-inch screen, retained on 10-mesh sieve	0.4
Passing 10-mesh sieve, retained on 20-mesh sieve	1.0
Passing 20-mesh sieve, retained on 30-mesh sieve	2.0
Passing 30-mesh sieve, retained on 40-mesh sieve	3.0
Passing 40-mesh sieve, retained on 50-mesh sieve	3.0
Passing 50-mesh sieve, retained on 80-mesh sieve	4.8
Passing 80-mesh sieve, retained on 100-mesh sieve	2.2
Passing 100-mesh sieve, retained on 200-mesh sieve	4.6
Passing 200-mesh sieve	79.0
	100.0

SUMMARY OF COST DATA.

The cost data for the experiments described above are presented in Tables 22 to 24.

TABLE 22.—*Quantities and costs of materials.*

Item.	Quantity in work unit.	Kind of material.	Quantity of material.	Unit cost.		Total cost.	Remarks.
				Material unit.	Work unit.		
					Cents.		
Foundation repairs.	39,377.4 square yards.	Gravel (run-of-pit).	150 cubic yards.	$0.05	0.019	$7.50	Estimated.
Shoulders	50,160 linear feet.	do	2,500 cubic yards.	.05	.25	125.00	Do.
Surface, bituminous gravel concrete.	38,442.6 square yards.	Gravel	3,500 cubic yards.	.10	.91	350.00	Do.
		Asphalt	380.66 tons	15.00	14.59	5,609.90	As billed.
		Limestone dust	98 tons	6.00	1.53	588.00	Do.
		Pea gravel for seal coat.	365 tons	1.50	1.42	547.50	Do.
Surface, earth oil-asphalt.	934.8 square yards.	Earth	85 cubic yards.	.10	.90	8.50	Do.
		Asphalt	14.35 tons	15.00	23.02	215.25	Do.
Extra work		All materials				514.67	

TABLE 23.—*Labor cost.*

Item.	Quantity.	Operation.	Labor costs.	Unit labor costs.
				Cents.
Foundation	39,377.4 square yards	Shaping	$1,758.46	4.467
		Sprinkling	175.50	.445
		Rolling	310.31	.787
			2,244.27	5.699
Bituminous gravel concrete surface.	38,442.6 square yards	Hauling asphalt	547.75	1.424
		Mixing	5,826.62	15.156
		Hauling mix	2,553.06	6.640
		Setting headers	546.94	1.421
		Spreading mix	1,394.37	3.627
		Rolling	295.81	.765
		Sealing	506.50	1.315
		Hauling pea gravel	299.26	.777
			11,970.31	31.125
Earth oil-asphalt surface	934.8 square yards	Mixing	231.75	24.79
		Hauling	105.25	11.26
		Setting headers	9.00	.96
		Spreading	83.56	8.93
			429.56	45.94
Gravel shoulders	50,160 linear feet	Loosening and loading	888.84	1.772
		Hauling	1,310.06	2.611
		Spreading	953.15	1.899
		Rolling	16.00	.031
			3,168.05	6.313

TABLE 24.—*Summary of material and labor costs.*

Item.	Quantity in working unit.	Total cost.	Cost per work unit.
Foundation:			*Cents.*
Material	39,377.4 square yards	$7.50	0.019
Labor		2,244.28	5.699
Total			5.718
Shoulders:			
Material	50,160 linear feet	125.00	.25
Labor		3,168.05	6.31
Total			6.56
Surface:			
Bituminous concrete material	38,442.6 square yards	7,095.40	18.45
Labor		11,970.31	31.13
Total			49.58
Surface:			
Earth oil-asphalt material	934.8 square yards	223.75	23.92
Labor		429.56	45.95
Total			69.87
Incidental expense		7,000.00	
Extra work		1,230.10	
Total cost		33,493.95	

The above cost data are based on the following unit prices of labor:

Foremen	per day of 8 hours	$4.00
Rollermen and skilled laborers	do	4.00
Laborers	per day	1.60–2.40
Trucks	per hour	1.00
Teams	per day	4.50

SUMMARY OF EXPERIMENTS ON ALEXANDRIA-ACCOTINK ROAD.

The following describes the condition of the above experiments when inspected on January 11, 1917.

EXPERIMENT NO. 1.—BITUMINOUS GRAVEL CONCRETE.

The surface of this experiment is practically in perfect condition. Difficulty has been found already with the rutting of the right-hand shoulder going down steep grades, but at the time of inspection there was no indication that the edge of the surfacing had begun to shear.

EXPERIMENT NO. 2.—EARTH OIL ASPHALT.

This section never had an opportunity to dry out thoroughly, since freezing weather came on the day following its completion. During thaws it was kept in shape for some time with a road grader and small tandem roller, but at the time of inspection was rather badly rutted and broken through to the gravel foundation in two places.

EXPERIMENTS ON THE GUM SPRING-MOUNT VERNON ROAD, FAIRFAX COUNTY, VA.

BITUMINOUS SURFACE TREATMENT ON A NEW GRAVEL ROAD.

The Mount Vernon Road extends from Gum Spring, in a southerly direction, 2.05 miles to the Mount Vernon estate, and is wholly in

Fairfax County. This road had been reconstructed and surfaced with gravel only a few months before the experimental surface treatment was undertaken. The principal features of the road may be described briefly as follows:

Total width of road	24 feet.
Total width of gravel surface	16 feet.
Compacted depth of gravel (2 courses having respective depths of 3 and 5 inches)	8 inches.
Crown of road	½ inch to 1 foot.
Maximum grade	5 per cent.
Drainage conditions	Favorable.

Gravel for use in the original construction was obtained from the county pit, located about 500 feet south of station 0+00 at Gum Spring, and the Walker pit, located about 100 feet east of station 92+50. The gravel from the county pit was used from station 0+00 to station 48+00, while that from the Walker pit was used from station 48+00 to the south end of the road. The mechanical analysis for the material from each pit is shown in Tables 25 and 26.

TABLE 25.—*Mechanical analysis of sand-clay gravel from Walker pit, Fairfax County, Va.*

Totals retained.		Passing—	Retained on—	Per cent of sample.	Per cent of coarse aggregate.	Per cent of fine aggregate.
	Per cent.					
¾-inch screen	6.5	1-inch screen	¾-inch screen	6.5	21.4	
½-inch screen	15.9	¾-inch screen	½-inch screen	9.4	30.9	
¼-inch screen	30.4	½-inch screen	¼-inch screen	14.5	47.7	
10-mesh sieve	40.6	¼-inch screen	10-mesh sieve	10.2		14.7
20-mesh sieve	45.5	10-mesh sieve	20-mesh sieve	4.9		7.0
30-mesh sieve	59.2	20-mesh sieve	30-mesh sieve	13.7		19.7
40-mesh sieve	77.2	30-mesh sieve	40-mesh sieve	18.0		25.9
50-mesh sieve	85.3	40-mesh sieve	50-mesh sieve	8.1		11.6
80-mesh sieve	88.4	50-mesh sieve	80-mesh sieve	3.1		4.5
100-mesh sieve	88.9	80-mesh sieve	100-mesh sieve	.5		.7
200-mesh sieve	89.6	100-mesh sieve	200-mesh sieve	.7		1.0
		200-mesh sieve		10.4		14.9
				100.0	100.0	100.0

TABLE 26.—*Mechanical analysis of sand-clay gravel from county pit.*

Totals retained.		Passing—	Retained on—	Per cent of sample.	Per cent of coarse aggregate.	Per cent of fine aggregate.
	Per cent.					
1-inch screen	4.8	1¼-inch screen	1-inch screen	4.8	8.6	
¾-inch screen	15.6	1-inch screen	¾-inch screen	10.8	19.3	
½-inch screen	34.6	¾-inch screen	½-inch screen	19.0	34.0	
¼-inch screen	55.9	½-inch screen	¼-inch screen	21.3	38.1	
10-mesh sieve	69.9	¼-inch screen	10-mesh sieve	14.0		31.7
20-mesh sieve	74.5	10-mesh sieve	20-mesh sieve	4.6		10.4
30-mesh sieve	80.3	20-mesh sieve	30-mesh sieve	5.8		13.2
40-mesh sieve	86.5	30-mesh sieve	40-mesh sieve	6.2		14.1
50-mesh sieve	88.6	40-mesh sieve	50-mesh sieve	2.1		4.8
80-mesh sieve	91.1	50-mesh sieve	80-mesh sieve	2.5		5.7
100-mesh sieve	92.0	80-mesh sieve	100-mesh sieve	.9		2.0
200-mesh sieve	93.7	100-mesh sieve	200-mesh sieve	1.3		2.9
		200-mesh sieve		6.7		15.2
				100.0	100.0	100.0

The traffic over this road varies considerably from season to season and has not yet been studied in detail. It consists for the most part of tourist automobiles going to and from Mount Vernon, which accounts for the extreme variability. It is planned to make periodic counts of the traffic, and to publish the results in future progress reports.

The purpose of the experiments was to gain information regarding the results to be obtained by using certain bituminous materials in the surface treatment of gravel roads. Three different materials were used, and the road was divided into three sections, according to the kind of bituminous material in the surface. Section 1 extends from station 0+00 to station 23+55; section 2 from station 23+55 to station 85+45, and section 3 from station 85+45 to station 109+00. Before taking up the description of the experiments separately, the data common to all three will be stated briefly.

The work was done by contract between November 3 and December 5, 1916, during which time there were only 15 weather working days. The contract prices are given in the latter part of this report.

In all of the experiments the road first was swept clean with a horse-drawn rotary broom, followed by men with push brooms. The bituminous material was applied under pressure of about 15 pounds per square inch by means of a motor truck distributor of a capacity of 1,200 gallons. The spray line of the distributor was 8 feet long and covered one-half the width of the road at a trip.

The top-dressing for all of the surface treatments was obtained from the Walker gravel pit and consisted of pit-run gravel from which the coarser particles had been screened out. The screening was done by hand, and the screen used had approximately 1-inch opening and was inclined at an angle of about 45°. As shown by the mechanical analysis of this material, given in Table 25, comparatively few particles passed the screen that would not pass a ½-inch mesh laboratory screen. The gravel top-dressing was hauled out in a 5-ton automobile truck and distributed in piles about 30 feet apart along the road. The spreading was done by hand.

EXPERIMENT NO. 1.—SURFACE TREATMENT WITH COAL-TAR PREPARATION, APPLIED COLD.

Location, station 0+00 to station 23+55.
Total length, 2,355 feet.
Total area, 4,187 square yards.

The tar used in this experiment was hauled from Washington in the auto distributor, and applied at the average rate of 0.49 gallon per square yard. Table 27 shows the analysis of the tar. The temperature of the material at the time it was applied was about 150° F.

TABLE 27.—*Analysis of coal-tar preparation*[1] *used on experiment No. 1 and for first application on experiment No. 3.*

Specific gravity, 25°/25° C	1.145	
Specific viscosity, Engler, 40° C., 50 c. c	14.4	
Per cent free carbon	6.24	
Distillation:		
	Per cent by volume.	Per cent by weight.
Water	0.0	0.0
First light oils (110° C.)	0.4	0.3
Second light oils (110–170° C.)	1.7	1.0
Heavy oils (170°–270° C.)	24.6	21.1
Heavy oils (270°–300° C.)	9.2	8.0
Pitch residue	64.1	69.6
Total	100.0	100.0

It had been planned to allow the tar to stand for several hours after it had been applied to the road before covering it with the gravel top-dressing, but the tendency of the material to run off the road was so great that it was found necessary to cover it immediately after the distributor had finished applications. The gravel was spread at a fairly uniform rate of 1 cubic yard to 78 square yards of surface.

The only noticeable lack of uniformity in the workmanship on this experiment is where the cut-off valve of the distributor failed to work properly on a return trip, with the result that a double application of tar was made on the west half of the road from station 13+50 to station 15+00. It also was necessary, of course, to increase the amount of gravel top-dressing on this part of the experiment.

EXPERIMENT NO. 2.—SURFACE TREATMENT WITH ASPHALTIC OIL, APPLIED HOT, AND CLAY GRAVEL.

Location, station 23+55 to 85+45.
Total length, 6,140 feet.
(Equality station decreases length of section 50 feet.)
Total area, 10,915 square yards.

The bituminous material used in this experiment was shipped to Alexandria in tank cars. At the Alexandria siding the oil was heated and pumped into the auto distributor, in which it was hauled 7 miles to the road. The material was heated to a temperature of about 200° F. and there was no appreciable loss of temperature during the haul. The analysis of the oil is shown in Table 28.

---

[1] Fairly thin fluid.

TABLE 28.—*Analysis of residual asphaltic petroleum*[1] *used on experiment No. 2.*

Specific gravity, 25°/25° C	0.995
Specific viscosity, Engler, 100° C., 50 c. c	17.5
Float test, 50° C. (seconds)	36
Loss, 163° C., 5 hours, 20 grams, (per cent)	13.56
Float test on residue, 50° C. (seconds)	232
Per cent of total bitumen insoluble in 86° B naphtha	20.12
Fixed carbon (per cent)	10.79
Soluble in CS_2 (total bitumen per cent)	99.87
Organic matter insoluble (per cent)	.11
Inorganic matter insoluble (per cent)	.02
Total	100.00

The first tank car of oil delivered at Alexandria was found to be low in viscosity and was rejected as not conforming to the specification. This rejection occasioned a delay of about two weeks in securing the oil for experiment No. 2, during which time experiment No. 3 was completed. When the contractor was ready to resume work on experiment No. 2, bad weather had set in and further delay was occasioned. Finally, it was deemed expedient to complete the experiment, although the weather conditions were not altogether favorable, because it was feared that long-continued bad weather might make it necessary to postpone the work until the next season. The oil accordingly was applied on the first warm day, regardless of the fact that the road surface was damp. The oil was applied 0.53 gallon per square yard, while the rate for gravel top-dressing was the same as in experiment No. 1, or 78 square yards to 1 cubic yard. No lack of uniformity in the distribution of either the oil or the gravel was noticed. Where successive distributor loads of oil joined, care was exercised to prevent overlapping, and there was no unevenness at any of the joints. From station 85+00 to 85+45, however, the gravel surface on the east side of the road was not very well bonded when the work was done.

EXPERIMENT NO. 3.—SURFACE TREATMENT USING TWO APPLICATIONS OF TAR.

First application of coal-tar preparation applied cold; second application refined coal tar, applied hot.

Location, station 85+45 to 109+00.
Total length, 2,355 feet.
Total area, 4,187 square yards.

Both kinds of tar for this experiment were hauled in the distributor from Washington, about 15 miles, to the road. The first application was of the same material as used on experiment No. 1, analysis of which is shown in Table 27. This application was made in a manner similar to that employed on experiment No. 1, except that the rate at which the tar was applied was only 0.35 gallon per square yard, and only sufficient gravel top-dressing was used to prevent the wheels of the distributor from picking up the surface while making the second application. Two days were allowed to elapse between the first and second applications.

---

[1] Viscous, sticky fluid.

TABLE 29.—*Analysis of refined coal tar* [1] *used on experiment No. 3, second application.*

Specific gravity, 25°/25° C	1.207	
Float test, 32° C. (seconds)	117	
Per cent free carbon	11.02	
Distillation:		
	Per cent by volume.	Per cent by weight.
Water	0.0	0.0
First light oils (110° C.)	0.0	0.0
Second light oils (110–170° C.)	0.0	0.0
Heavy oils (170–235° C.)	5.0	3.9
Heavy oils (235–270° C.)	12.2	10.2
Heavy oils (270–300° C.)	7.6	6.4
Pitch residue	75.2	79.5
Total	100.0	100.0

The tar for the second application is represented by the analysis shown in Table 29. This material was heated at the plant in Georgetown, so that when it reached the work the temperature was about 205° to 220° F. It was spread at the average rate of 0.50 gallon per square yard. Immediately after the second application of tar the surface was covered with the gravel top-dressing, spread at the rate of 1 cubic yard to about 78 square yards of surface. The amount of top-dressing required for the two applications was 1 cubic yard of gravel to 53.7 square yards of surface.

The places where a noticeable lack of uniformity occurred in the work are:

(1) In making the first application the distributor moved too slowly on the east side of the road from station 98+50 to 100+00 and the tar was applied over this area at the rate of about one-half gallon to the square yard.

(2) In making the second application an excess of tar was deposited at station 85+45, where experiments 2 and 3 join.

(3) The second application was made in cold weather and the tar chilled so that little of the gravel top-dressing sank into it. Later, when the road was opened to traffic, it was observed that much of the top-dressing had been swept off the road surface by passing vehicles.

---

[1] Sticky, very viscous.

(4) The work on this experiment was delayed because of bad weather, but the old road surface was uniformly in fairly good condition when the work was done.

Cost data.

The bid prices were based on furnishing and placing the materials by the material unit and were as follows:

1. Light coal-tar preparation in place, per gallon	$0.16
2. Heavier coal-tar preparation in place, per gallon	.16
3. Asphaltic oil in place, per gallon	.17
4. Gravel for top-dressing in place, per cubic yard	1.05

At the above unit prices the costs per square yard for the different experiments were:

	Cents.
For experiment No. 1 (cold tar)	9.18
For experiment No. 2 (residual asphaltic petroleum)	10.32
For experiment No. 3 (2 applications of tar—1 cold, 1 hot)	15.26

Total contract price for the three experiments, $2,149.57.

During the progress of the work, and with the cooperation of the contractor, a record was kept of both the labor employed and materials used. Tables 30 and 31 show an itemized summary of the costs to the contractor, which are based on the following scale of unit costs:

Foreman, per hour	$0.50
Laborers, per hour	.25
Helper on truck distributor, per hour	.30
Driver for truck distributor, per hour	.40
Auto truck for hauling gravel (including driver and supplies), per hour	2.00
Auto truck distributor (including driver and supples), per hour	3.00
Boiler for heating asphaltic oil (including fireman and supplies) per hour	1.00

TABLE 30.—*Cost data for excavating, screening, and hauling gravel for top-dressing.*

Item.	Quantity.	Total cost.	Unit cost, per cubic yard.
	Cubic yards.		
Loosening gravel	271	$56.50	$0.2085
Screening gravel	271	53.50	.1974
Loading and dumping gravel	271	46.00	.1697
Hauling gravel[1]	271	184.00	.6789
Stripping pit	271	4.00	.0147
Gravel in pit	271	13.55	.05
Total	271	357.55	1.3192

[1] Average haul for gravel, 3,900 feet. The high cost of hauling is due to the use of an auto truck that could be kept running but a small portion of the time.

TABLE 31.—*Contractor's cost of surface treating Mount Vernon experimental road, by experiments.*

Item.	Experiment No. 1.			Experiment No. 2.			Experiment No. 3.		
	Quantity.	Cost.	Cost per square yard.	Quantity.	Cost.	Cost per square yard.	Quantity.	Cost.	Cost per square yard.
			Cents.			*Cents.*			*Cents.*
General expenses.		$28.00	0.669		$39.20	0.359		$90.40	2.159
Sweeping road	4,187 square yards.	7.00	.167	10,915 square yards.	18.00	.165	4,187 square yards.	20.00	.478
Distributing oil or tar.	2,048 gallons.	52.80	1.261	5,766 gallons.	108.00	.989	3,557 gallons.	128.80	3.076
Heating oil				5,766 gallons.	88.00	.806			
Spreading gravel.	54 cubic yards	14.00	.334	139 cubic yards.	65.20	.598	78 cubic yards	34.00	.812
Oil or tar	2,048 gallons, at 8½ cents.	174.08	4.157	5,766 gallons, at 8 cents.	461.28	4.226	1,482 gallons, at 8½ cents. 2,075 gallons, at 8½ cents.	125.97 176.38	3.009 4.212
Gravel	54 cubic yards	71.23	1.701	139 cubic yards.	183.37	1.680	78 cubic yards	102.90	2.457
Total		347.11	8.289		963.05	8.823		678.45	16.203

SUMMARY OF EXPERIMENTS ON GUM SPRING-MOUNT VERNON ROAD, FAIRFAX COUNTY, VA.

The following report describes the condition of the above experiments when inspected on January 11, 1917:

EXPERIMENT NO. 1.—COAL-TAR PREPARATION.

The surface is breaking rapidly and becoming mealy, particularly up the grade at the beginning of the experiment. There is no well-formed mat; deterioration during the 10 days preceding inspection was noticeably rapid.

EXPERIMENT NO. 2.—RESIDUAL ASPHALTIC PETROLEUM.

The surface has a very uniform mat for short distances, alternating with areas which have become badly rutted. The rutting has occurred both in cut and in fill, and in at least two places the red clay subgrade has worked through the gravel.

EXPERIMENT NO. 3.—COAL-TAR PREPARATION AND COAL TAR REFINED.

This experiment shows a fairly intact surface, with a rather well-formed mat. It has only two or three small areas with any ruts whatever, and is not badly rutted anywhere.

EXPERIMENTS WITH PIPE CULVERTS OF CORRUGATED METAL ON THE TEXAS POST ROAD IN COMAL AND HAYS COUNTIES, TEX.

GALVANIZED AND UNGALVANIZED PIPE MADE OF VARIOUS KINDS OF IRON AND STEEL.

These experiments are for the purpose of comparing the behavior of different kinds of iron and steel when used in corrugated pipe culverts under the conditions prevailing in Comal and Hays Counties, Tex. All of the culverts were placed in the spring and summer of 1915 and were in perfect condition when placed. They are reported on at this time in order to describe their condition when inspected in March, 1917.

The pipe used was all 24 inches in diameter and made of 14 gauge (U. S. standard) metal. Both galvanized and ungalvanized sheets were used. The culvert structures are all provided with concrete head walls and include from one to four lines of pipe. Table 32 gives the number, location, and a brief description for each culvert. In all cases the structure numbers are indented in the tops of the head walls. The engineer's stationing, used in fixing the locations, is as follows:

In Hays County.—Station numbers increase southward from 1,357 at the Blanco River to station 1986, Hays-Comal County line. In Comal County the station numbers decrease southward from 539 + 16 (= station 1986, Hays County survey), at the Hays-Comal County line to 0 at the north city limits of New Braunfels, and increase southward from 539 + 16 at the south city limits of New Braunfels to 1045 + 27 at the Comal-Guadalupe County line.

Tables 33 and 34 show the results of laboratory analyses of samples taken from the galvanized and ungalvanized pipe, respectively. The samples in all cases were 4-inch by 6-inch rectangles, and were cut before the pipes were placed.

Table 35 records the condition of the various pipes when inspected in March, 1917.

TABLE NO. 32.—*Locations of experimental culverts, Texas post road.*

Landmarks and culvert No.	Station No.	Number lines of pipe.	Description of culverts or landmarks.
Hays County	1357		South bank of Blanco River.
No. 62	1419	1	Ungalvanized Bessemer steel.
No. 65	1457+50	1	Galvanized Bessemer steel.
No. 68	1515	1	Do.
San Marcos	1584 1675		North city limits, San Marcos River. South city limits, San Marcos River.
No. 74	1748+70	1	Galvanized open-hearth steel.
No. 75	1765+35	1	Ungalvanized Bessemer steel.
County line	1986 539+16		Hays County survey. Comal County survey.
No. 94. I. & G. N. R. R. crossing,	508	1	Galvanized copper-bearing open-hearth steel.
No. 97	476+10	1	Ungalvanized copper-bearing iron.
No. 98	466+60	1	Ungalvanized copper-bearing steel.
No. 101	393+85	1	Galvanized copper-bearing steel.
No. 103. Under concrete crossing,	355+00	1	Ungalvanized ingot iron.
No. 109	168	4	North, galvanized Bessemer steel. North center, ungalvanized open-hearth steel. South center, galvanized open-hearth steel. South, ungalvanized Bessemer steel.
No. 110	112+50	2	North, galvanized open-hearth steel. South, ungalvanized open-hearth steel.
New Braunfels	0 539+16		North city limits, Guadalupe River. South city limits.
No. 127	716	2	North, galvanized ingot iron. South, galvanized copper-bearing iron.
No. 128	726	2	North, ungalvanized copper-bearing iron. South, galvanized copper-bearing iron.
No. 131	777	2	North, ungalvanized open-hearth steel. South, ungalvanized copper-bearing open-hearth steel.
Railroad crossing	791		M. K. & T. R. R.
No. 134	815	1	Galvanized ingot iron.
No. 143	937	4	North, galvanized copper-bearing open-hearth steel. North center, galvanized copper-bearing iron. South center, ungalvanized copper-bearing iron. South, ungalvanized copper-bearing open-hearth steel
No. 148	1012	1	Ungalvanized ingot iron.
No. 149	1018	2	North, galvanized ingot iron. South, ungalvanized ingot iron.
County line	1045+27		Comal, Guadalupe Counties.

TABLE NO. 33.—*Tests on galvanized metal used in experimental corrugated culverts on Texas post road.*

Metal.	Structure No.	Spelter per square foot of metal.	Analysis of base metal.					
			Carbon.	Sulphur.	Phosphorus.	Manganese.	Copper.	Silicon.
		Ounces.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
Galvanized Bessemer steel	109	2.97	0.11	0.052	0.098	0.34	0.00	0.005
Do	65	2.59	.09	.047	.107	.36	.004	....
Do	68	2.80	.10	.053	.104	.37	.002	....
Galvanized open-hearth steel	109	2.74	.09	.043	.013	.41	Trace.	....
Do	110	2.58	.10	.049	.017	.40	.008	....
Do	74	2.84	.09	.037	.037	.39	.003	....
Galvanized copper-bearing steel	94	2.48	.07	.033	.0095	.32	.12	....
Do	101	2.59	.07	.036	.0095	.41	.20	....
Do	143	2.48	.08	.048	.0095	.42	.22	....
Galvanized copper-bearing iron	127	1.90	.04	.039	.012	.056	.12	....
Do	128	1.86	.05	.040	.0095	.056	.13	....
Do	143	2.02	.04	.034	.0074	.050	.12	....
Galvanized ingot iron	127	2.44	.04	.044	.0063	.019	.06	....
Do	134	2.41	.03	.035	.0074	.050	.04	....
Do	149	2.50	.03	.045	.0063	.019	Trace.	....

TABLE NO. 34.—*Tests on ungalvanized metal used in experimental corrugated culverts on Texas post road.*

Metal.	Structure No.	Analysis of metal.					
		Carbon.	Sulphur.	Phosphorus.	Manganese.	Copper.	Silicon.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Bessemer steel	109	0.12	0.057	0.097	0.34	0.000	....
Do	62	.10	.045	.099	.37	.004	....
Do	75	.10	.049	.096	.37	.004	....
Open-hearth steel	109	.09	.042	.014	.36	Trace.	0.005
Do	110	.08	.040	.017	.26	.004	....
Do	131	.08	.048	.012	.38	.04	....
Copper-bearing steel	98	.07	.032	.0084	.32	.22	.015
Do	131	.09	.057	.013	.43	.15	....
Do	143	.08	.057	.012	.43	.22	....
Copper-bearing iron	97	.04	.036	.0084	.043	.12	.01
Do	128	.05	.040	.0095	.056	.12	....
Do	143	.04	.035	.012	.019	.12	....
Ingot iron	103	.02	.022	.0053	.028	.006	.00
Do	148	.03	.032	.0074	.028	.016	....
Do	149	.03	.027	.0053	.028	.012	....

TABLE 35.—*Condition Record March, 1917.*

Metal.	Structure No.	Location.	Position.	Condition, March, 1917.
		Station.		
Galvanized Bessemer steel	109	168+00	North	In apparently new condition. No deterioration of spelter, and entire absence of scale or rust.
Do	65	1457+50	....	Do.
Do	68	1515	....	Do.
Galvanized open-hearth steel	109	168+00	South center	Do.
Do	110	112+50	North	Do.
Do	74	1748+70	....	Do.
Galvanized copper-bearing steel	94	508	....	Do.
Do	101	393+85	....	Do.
Do	143	937+00	North	Do.
Galvanized copper-beraing iron	127	716+00	South	Do.
Do	128	726+00	do	Do.
Do	143	937+00	North center	Do.
Galvanized ingot iron	127	716+00	North	Do.
Do	134	815+00	....	Do.
Do	149	1018+00	North	Do.

TABLE 35.—*Condition Record, March, 1917*—Continued.

Metal.	Structure No.	Location. *Station.*	Position.	Condition, March, 1917.
Ungalvanized Bessemer steel	109	168+00	South	Considerably rusted and starting to scale slightly. Rust removed with effort, and deterioration of metal noted to a small extent on scaled spots.
Do	62	1419		Slight coating of rust, easily removed. No scale or deterioration of metal noted.
Do	75	1765+35		Do.
Ungalvanized open-hearth steel	109	168+00	North center	Slight coating of rust, easily dusted off. No scale or deterioration of metal noted.
Do	110	112+50	South	Considerably rusted and starting to scale slightly. Rust removed with difficulty, and deterioration of metal noted to a small extent on scaled spots.
Do	131	777+00	North	Considerably rusted. Coating removed only with effort. No scaling or deterioration of metal noted.
Ungalvanized copper-bearing steel.	98	466+60		Slight coating of rust easily dusted off. No scale or deterioration of metal.
Do	131	777+00	South	Considerably rusted. Coating removed only with effort. No scaling or deterioration of metal noted.
Do	143	937+00	do	Considerably rusted. Coating easily removed. No scaling or deterioration of metal noted.
Ungalvanized copper-bearing iron.	97	476+10		Slight coating of rust, easily dusted off. No scale or deterioration of metal noted.
Do	128	726+00	North	Do.
Do	143	937+00	South center	Considerably rusted. Coating easily removed. No scaling or deterioration of metal noted.
Ungalvanized ingot iron	103	355+00	Under concrete crossing.	Considerably rusted and starting to scale slightly. Rust removed with effort, and deterioration of metal noted to a small extent on scaled spots.
Do	148	1012+00		Considerably rusted. Coating of rust easily removed. No scaling or deterioration of metal noted.
Do	149	1018+00	South	Considerably rusted. Coating removed only with effort. No scale or deterioration of metal noted, but certain few spots indicate early formation of scale.

SUPPLEMENTARY REPORTS OF EXPERIMENTS PREVIOUSLY REPORTED.

The following reports are in continuation of others already published by the department in the annual "Progress Reports of Experiments in Dust Prevention and Road Preservation." It was decided to abandon the experiments at Ames, Iowa, and Knoxville, Tenn., but the histories of these experiments as well as of several others are summarized with the supplementary reports, so that the results obtained may be studied conveniently by those interested. In all cases references are made to the earlier publications in which reports regarding the various projects have appeared.

MOUNT VERNON AVENUE, ALEXANDRIA COUNTY, VA., 1915.

BITUMINOUS MACADAM, BITUMINOUS CONCRETE, BITUMINOUS GRAVEL CONCRETE.

These experimental sections were constructed on Mount Vernon Avenue beginning at the Military Road near Arlington Cemetery and extending to Washington Avenue; thence to Washington Street, to the city line of Alexandria. The original report, giving details of materials and methods of construction, is published in Bulletin No. 407, United States Department of Agriculture. In addition, it may be stated that experiments Nos. 1 and 2, and 5 to 10, inclusive, bled profusely with the first warm weather of the spring of 1916, and required the prompt application of torpedo sand to prevent picking up under traffic.

The work was inspected on January 11, 1917, and the condition of the experimental sections at that time was as follows:

Experiment No. 1—Bituminous macadam, sandstone with fluxed native asphalt A; experiment No. 2—Bituminous macadam, sandstone with oil-asphalt X.—There was no marked difference in the appearance of these experiments. They were in excellent condition, with the seal coat still almost intact, particularly on experiment No. 1, the bitumen having bled up to form a close, generally uniform surface. Experiment No. 2 appeared to have more of the coarse stone exposed. Only two or three patches have been made since construction.

Experiment No. 3—Bituminous concrete, sandstone with fluxed native asphalt A; experiment No. 4—Bituminous concrete, sandstone with oil-asphalt X.—In January, 1916, about 6 months after completion, it was noticed that large areas in both of these experiments became covered with check cracks, generally in two directions—longitudinally and at right angles to traffic. From 24 to 48 hours after the appearance of these cracks the areas would begin to ravel, and, once broken, disintegration would follow rapidly. Temporary repairs were provided for at once and only a few of the cracked areas actually broke. Those which raveled were dug out carefully and filled with penetration patches until, in March, it was possible to apply a general seal coat to both experiments. A fluid, refined water-gas tar was used and the covering material was torpedo sand. The characteristics of the bituminous material are given in Table 36, and the cost data and quantities will be found in Table 38.

TABLE 36.—*Analysis of refined water-gas tar.*

Specific gravity 25° C/25° C	1.145
Specific viscosity, Engler, 50° C. 50 c. c.	[1] 26.5
Bitumen soluble in CS_2 (total bitumen) per cent	98.92
Organic matter insoluble (free carbon) do	1.05
Inorganic matter insoluble do	0.03
	100.00

---

[1] Average of three samples.

TABLE 36.—*Analysis of refined water-gas tar*—Continued.

Distillation:	Character.	Per cent by volume.	Per cent by weight.
Water		0.0	0.0
First light oils (110° C.)		0.0	0.0
Second light oils (−110°–170° C.)	Clear.	Trace.	Trace.
Heavy oils (170°–270° C.)	2/25 solid	28.0	24.5
Heavy oils (270°–300° C.)	Clear.	10.3	9.0
Pitch	Sticky; semisolid.	61.7	66.5
		100.0	100.0

This treatment prevented further deterioration, although experiment No. 4 has a somewhat distorted cross section at points where the heavy sidehill fill has settled. At the time of inspection both of these experiments presented a practically uniform appearance. The surface was intact, although the seal coat was blotchy, some areas were black and leathery where fat areas had been caused by the penetration patches in the original surface, and other places were brown and mosaic in texture.

Experiment No. 5—Bituminous macadam, gneiss with fluxed native asphalt A; experiment No. 6—Bituminous macadam, gneiss with oil-asphalt X.—These experiments were somewhat open and porous in the spring of 1916, but at the time of inspection were in good condition, having sealed themselves satisfactorily. To prevent raveling, a few patches had to be made early in the year before warm weather caused bitumen to bleed to the surface. The seal coat is now fairly uniform, although several mosaic areas were noted, and the surface is somewhat rough, owing to irregularities from construction rather than to wear.

Experiment No. 7—Bituminous concrete, gneiss with oil-asphalt X; experiment No. 8—Bituminous concrete, gneiss with fluxed native asphalt A.—These experiments were somewhat smoother than experiments Nos. 5 and 6. Not having been so open in the spring of 1916, the bleeding above referred to produced a more uniform mat, and the surface was in good condition, except for slight irregularities.

Experiment No. 9—Bituminous gravel concrete, pit-run gravel with oil-asphalt Y.—This experiment was somewhat rough and uneven, owing to irregularities apparently due to lack of uniformity in the seal coat; otherwise the experiment was in good condition. Only one or two small areas raveled in the spring of 1916, but were repaired easily.

Experiment No. 10—Bituminous gravel concrete, pit-run gravel with fluxed native asphalt B.—This was the poorest of the gravel sections. A considerable total area, almost all being on the Four Mile Run fill, required patching early in 1916, and practically the entire surface received a seal coat in intermittent applications. The mixing plant used in construction stood at approximate station 95 and much of the construction work south of Hume Spring was done after the surface of experiment 10 was laid. On account of the dripping of the bitumen from the mix as it was hauled over the section, a blotchy, irregular seal coat characterized this experiment. This blotchy effect was practically all worked out of the surface by careful maintenance, although it still was full of slight, short irregularities. On the whole, the experiment was in better condition than during the spring and early summer of 1916.

Experiment No. 11—Bituminous gravel concrete, pit-run gravel with refined tar.—This experiment had a browner, more open appearance than any other gravel section. It had to be slightly patched in the summer of 1916, but at the time of inspection was intact and in good condition, except for slight irregularities due to construction.

Experiment No. 12—Bituminous gravel concrete, pit-run gravel with oil-asphalt Y.—This experiment, especially the part between the railroad crossing, was much the best of the gravel sections. It had an even, regular, somewhat leathery mat, and was practically free from irregularities. At the crest of the grade between the railroads a spring broke through the road during the early summer and a stone drain had to be laid. Except for repairs at this place, the surface required very little attention. Only one spot showed bad wear, and that was at Hume Station, where the mixed work joins the brick crossing.

Experiment No. 13—Bituminous macadam, trap rock with oil-asphalt X; Experiment No. 14, bituminous macadam, trap rock with fluxed native asphalt A.—These experiments were very open and porous at the time of completion, and one or two small patches had to be made to prevent raveling. The binder bled up satisfactorily, and at the time of inspection the surfaces presented no apparent difference and were intact and in good condition.

Experiment No. 15—Bituminous concrete, trap rock with fluxed native asphalt A; Experiment No. 16, Bituminous concrete, trap rock with oil-asphalt X.—Within 4 months after completion these experiments began to ravel badly and experiment No. 16 failed over 60 per cent of its area. As the failure occurred during the winter months, it was impossible to make proper bituminous patches, so repairs were made by removing the old surface where disintegrated and filling the holes with a good sand-clay gravel and allowing it to compact under traffic. These areas were fairly smooth by spring and then were treated with a heavy seal of cold water-gas tar or coal-tar patching material and covered with ⅜-inch gravel. At the time of inspection both sections were in good condition, although slightly rough in some places. The largest breaks in the original surface occurred on the fill at approximate station 191, and although a sharp turn occurs at station 192, the repairs made appear to have been adequate.

Experiment No. 17—Bituminous macadam, granite with fluxed native asphalt; experiment No. 18, Bituminous macadam, granite with oil-asphalt X.—In the spring of 1916 small areas, distributed quite generally over the surface of both experiments, began to disintegrate so that numerous penetration patches were necessary. These sections had been laid over old macadam which was scarified and dressed with a layer of new stone before the penetration course was applied. The breaking of the newly constructed surface appeared to be due to movement in the wearing surface caused by the failure to fill and bond the new stone added to the foundation. Both sections were in good condition for retreatment and this was applied. The characteristics of the bituminous material used in the reseal are given in Table 37 and the cost data and quantities will be found in Table 38.

TABLE 37.—*Analyses of residual asphaltic petroleum.*[1]

General characteristics, viscous, sticky fluid.	
Specific gravity 25° C./25° C	A—0.991 B—0.989
Flash point ° C	100
Burning point ° C	120
Float test 50° C. (seconds)	A—30 B—30
Viscosity Engler 50 c. c. at 100° C., specific	14.2
Loss at 163° C., 5 hours, 20 grams, per cent	14.30
Character of residue very viscous, sticky.	
Float test on residue 50° C. (seconds)	160
Per cent of total bitumen insoluble in 86° B., naphtha	17.39
Per cent of fixed carbon	10.44
Bitumen soluble in CS_2 (total bitumen), per cent	99.89
Organic matter insoluble, per cent	0.11
Inorganic matter insoluble, per cent	0.00
	100.00

Experiment No. 19—Bituminous concrete, granite with oil-asphalt X.—This experiment showed marked deterioration and many penetration patches had to be made in the spring of 1916. It was brought into good condition for treatment and a new seal coat applied in May and June, 1916. The same bituminous material was used as on experiments Nos. 17 and 18, and cost data and quantities are given in Table 38. At the time of inspection this experiment showed a few wavy spots due to fat penetration patches under the retreatment; otherwise the experiment was in good condition.

Experiment No. 20—Bituminous concrete, granite with fluxed native asphalt A.—Except at the south end, this experiment did not disintegrate so noticeably as the other three granite sections. It was placed in good condition with penetration patches and received a surface treatment in May. The same bituminous material was used as for the treatment on experiments Nos. 17, 18, and 19, and cost data and quantities are given in Table 38. At the time of inspection this experiment was in almost perfect condition.

---

[1] Samples A and B from each of 2 barrels, except where indicated tests were made on composite sample.

Corrugated metal culverts.—The corrugated metal culverts on the Mount Vernon Avenue experimental road were inspected at the same time as the road surface, and were found to be in good, sound condition. There was no appreciable difference in the amount of rusting, although all were covered with a thin layer of rust. In the case of the coppered-iron and ingot-iron culverts this rust seemed to be somewhat more easily rubbed off than in the case of the others, leaving smooth black metal exposed. The rust in the open-hearth steel culverts appeared to be of a more scaly nature than in the others.

Table 40 shows a traffic census record for the entire project, and Table 39 the maintenance cost record for the calendar year. The cost figures in Table 39 include the cost of surface retreatments given in Table 38.

TABLE 38.—*Material and cost data of re-treatments in 1916 on Mount Vernon Avenue.*[1]

Experiment No.	Bituminous material.	Date of treatment.	Area of experiment.	Quantity of material per square yard.			Cost per square yard.							
				Bituminous material.	Gravel.	Sand.	Bituminous material.	Gravel.	Sand.	Cleaning surface.	Applying bituminous material.	Applying sand or gravel.	Supervision.	Total.
		1916.	*Sq. yds.*	*Gal.*	*Cu. yds.*	*Cu. yds.*	*Cent.*	*Cent.*	*Cent.*	*Cent.*	*Cent.*	*Cent.*	*Cent.*	*Cent.*
3	Water-gas tar, refined	Mar. 7-8	1,867.8	0.419	....	0.0161	03.36	....	03.55	00.21	00.17	00.13	00.80	08.49
4	do	Mar. 9-11	1,924	.408	....	.0156	03.26	....	02.49	00.17	00.17	00.13	01.03	07.26
17	Res. asph. petroleum	June 8-12	1,422	.342	0.0163	....	03.14	05.09	....	00.23	01.12	00.30	01.05	10.93
18	do	June 3-7	1,580	.346	.0163	....	03.16	04.66	....	00.34	00.64	00.21	00.88	09.89
19	do	May 29-June 2	1,728	.348	.0165	....	03.18	04.29	....	00.19	00.64	00.25	00.72	09.27
20	do	May 25-28	1,867	.335	.0162	....	03.05	04.47	....	00.16	00.39	00.15	00.70	08.96

---

[1] These costs are included in the maintenance given in Table 39.

TABLE 39.—*Surface maintenance costs of 1915 experiments on Mount Vernon Avenue, Alexandria, Va., from Jan. 1 to Dec. 31, 1916.*

Experiment No.	Area.	Cost per square yard.			Experiment No.	Area.	Cost per square yard.		
		Construction.	Maintenance.	Total.			Construction.	Maintenance.	Total.
	Sq. yds.	*Cents.*	*Cents.*	*Cents.*		*Sq. yds.*	*Cents.*	*Cents.*	*Cents.*
1	1,202.22	80.13	7.36	87.49	10	5,445.22	43.74	2.10	45.84
2	2,599.67	66.43	2.08	68.51	11	1,573.34	41.62	2.42	44.04
3	1,867.78	88.98	11.90	100.88	13	1,688.88	48.41	.92	49.33
4	1,924.00	74.27	10.06	84.33	14	1,777.78	58.98	1.61	60.59
5	2,196.56	47.74	2.95	50.69	15	1,742.22	65.77	.18	65.95
6	1,422.22	36.85	.52	37.37	16	1,621.34	52.66	3.24	55.90
7	2,369.78	45.57	.89	46.46	17	1,422.22	63.04	14.02	77.06
8	1,221.33	57.81	1.41	59.22	18	1,580.45	48.29	14.57	62.86
9	6,863.22	33.54	2.94	36.48	19	1,728.00	54.26	11.95	66.21
12					20	1,866.67	67.73	10.59	78.32

TABLE 40.—*Volume and character of traffic during a 16-hour period on Mount Vernon Avenue, Apr. 8 to Dec. 24, 1916.*

		North of Russell Road.				South of Russell Road.			
		Maximum.		Average.		Maximum.		Average.	
		North-bound.	South-bound.	North-bound.	South-bound.	North-bound.	South-bound.	North-bound.	South-bound.
1	Loaded 1-horse wagon	2	3	....	1	2	2	....	1
2	Unloaded 1-horse wagon	5	7	1	1	4	6	1	1
3	Loaded 2-horse wagon	2	6	....	....	2	4	....	1
4	Unloaded 2-horse wagon	4	2	1	1	4	2	1	....
5	Loaded 4-horse wagon	3	1	....	....	1	1	....	....
6	Unloaded 4-horse wagon	1	....	....	....	2	....	....	....
7	1-horse pleasure vehicle	7	7	2	3	7	7	2	2
8	2-horse pleasure vehicle	1	1	....	....	1	2	....	....
9	Rubber-tired horse vehicle	....	1	....	....	1	1	....	....
10	Saddle horse	96	8	5	1	3	6	1	1
11	Motor cycle	25	32	7	9	24	32	5	6
12	Excessively heavy vehicle [1]	1	3	....	....	1	3	....	....
13	Motor runabout	27	20	13	11	17	16	9	9
14	Motor touring car	715	720	270	257	451	470	201	190
15	Loaded motor dray	16	21	6	20	13	17	6	9
16	Unloaded motor dray	19	18	6	5	14	11	6	4

[1] Very heavy vehicles, such as carry ore, stone, timber, machinery, etc.

FALLS ROAD, MONTGOMERY COUNTY, MD., 1915.

SURFACE TREATMENT ON WATER-BOUND MACADAM (OILS, TAR PREPARATIONS, REFINED TARS).

The original report of these experiments was given in Bulletin No. 407, U. S. Department of Agriculture. The following report describes the condition of the experiments on February 21, 1917.

Experiment No. 1—Asphaltic petroleum, cold application, corresponding to experiment No. 3 on Rockville Pike.—This surface shows a tendency to become mealy in cold weather, and with continued wet weather works up into mud. It was seen in the winter of 1915–16 that the road could not be brought safely through another cold season, and a re-treatment was given late in the fall of 1916. The same material was used as for the original application, and its characteristics are given in Table 41. Cost data and quantities appear in Table 43. At the time of inspection the surface showed its characteristic tendency to work into mud, but had behaved much better as a whole than did the corresponding section on the Rockville Pike during a corresponding period after its construction.

TABLE 41.—*Analysis of asphaltic petroleum*[1] *used in re-treatment of experiment No. 1.*

Specific gravity 25°/25° C	0.956
Flash point (° C)	28
Burning point (° C.)	50
Specific viscosity, Engler, 25° C., 50 c. c	187.5
Loss at 163° C., 5 hours, 20 grams (per cent)	28.23
Float test on residue,[2] 50° C. (seconds)	188
Per cent of total bitumen insoluble in 86° B. naphtha	16.58
Fixed carbon (per cent)	9.04
Total bitumen (soluble in CS_2) per cent	99.95
Organic matter insoluble per cent	.05
Inorganic matter insoluble per cent	.00
	100.00

Experiment No. 2—Residual asphaltic petroleum, hot application, corresponding to experiment No. 5, on the Rockville Pike.—This section was in generally good condition. There was a slight tendency to crumble, especially at the edges, but little or no mud formed. It was thought very early in 1916 that this section would require retreatment during the summer, but it bled profusely and had to be dressed heavily until about the middle of the summer. The section appeared to be somewhat better than section No. 5 of the Rockville Pike.

Experiment No. 3—Coal-tar preparation, cold application.—The original application on this section never produced a close intact mat and in the summer of 1916 had to be patched frequently where the macadam had become exposed and in November was retreated with the same bituminous material as applied originally. The characteristics of the bituminous material appear in Table 42, and cost data and quantities in Table 43. At the time of inspection the experiment was in excellent condition, with no signs of further disintegration or unusual wear.

TABLE 42.—*Analysis of coal-tar preparation*[3] *used in retreatment of experiment No. 3.*

Specific gravity 25°/25° C	1.149
Specific viscosity, Engler 50 c. c. at 40° C	12.1
Per cent free carbon (insoluble in CS_2)	6.19

Distillation:	Per cent by volume.	Per cent by weight.
Water	0.0	0.0
First light oils[4] (to 110° C.)	1.8	1.1
Second light oils[4] (110° to 170° C.)	1.5	.8
Heavy oils[5] (170° to 270° C.)	19.8	17.1
Heavy oils[4] (270° to 300° C.)	9.0	7.8
Pitch residue	67.9	73.2
Total	100.0	100.0

---

[1] Fairly viscous sticky fluid.
[2] Very viscous sticky fluid.
[3] Fairly thin fluid.
[4] Clear.
[5] One-half solid.

TABLE 43.—*Materials and cost data for surface retreatment in 1916.*

Item.	Experiment No. 1 (asphaltic petroluem).	Experiment No. 3 (coal-tar preparation).
Area treated .... square yards..	7,625	13,235
Quantity of material per square yard:		
Bituminous material .... gallons..	0.23	0.33
Gravel .... cubic yards..	....	.0115
Sand .... do....	.0114+	....
Cost per square yard (cents):		
Bituminous material	2.52	3.06
Gravel	....	3.45
Sand	2.51	....
Cleaning surface	.10	.41
Hauling materials	.77	.14
Applying bituminous materials	.35	.49
Applying sand or gravel	.18	.24
Supervision	.35	.36
Total (cents)	6.78	8.15

Experiment No. 4—Refined water-gas tar, cold application, similar to experiment No. 2 on Rockville Pike.—This section has not shown the initial signs of disintegration characteristic of section 2 of the pike, which is troublesome unless cared for by immediate retreatment. Several intersecting bad roads tended to impair the character of the surface near the intersections owing to the clay that was tracked on the bituminous surface. The experiment was in good condition, but indications were that a second application of tar would be required in the early summer.

Experiment No. 5—Refined coal tar, hot application, similar to experiment No. 1 on the Rockville Pike.—This experiment was in generally good condition. It suffered a little near the cemetery, owing to large quantities of mud being brought upon it from side roads and drives. At the time of inspection there was no disintegration.

Following the same procedure used in connection with the other experimental roads, a traffic census was taken on the Falls Road for 15 hours every thirteenth day from April 10 to December 31, 1916. A tabulation of the maximum and average of each class of traffic for this period is given in Table 45. Table 44 shows comparative cost data to December 31, 1916, for the various experiments included in this project. The cost figures in Table 44 include the cost of general retreatments as given in Table 43.

TABLE NO. 44.—*Surface maintenance costs of 1915 experiments on Falls Road, Montgomery County, Md., from January 1 to December 31, 1916.*

Experiment No.	Length of section.	Area.	Cost per square yard.			Maintenance cost per mile of surface.
			Construction.	Maintenance.	Total.	
	Feet.	*Sq. yds.*	*Cents.*	*Cents.*	*Cents.*	
1	4,575	7,625	7.77	6.25	14.02	$550.00
2	4,386	7,310	12.11	1.07	13.12	94.16
3	7,941	13,235	8.48	9.33	17.80	821.00
4	5,718	9,530	9.63	.10	9.73	8.80
5	5,880	9,800	10.21	.01	10.22	.88

TABLE 45.—*Volume and character of traffic on Falls Road, Apr. 10 to Dec. 26, 1916.*

		Maximum.		Average.	
		West bound.	East bound.	West bound.	East bound.
1	Loaded 1-horse wagon	16	6	3	3
2	Unloaded 1-horse wagon	5	12	2	2
3	Loaded 2-horse wagon	10	17	3	4
4	Unloaded 2-horse wagon	12	4	3	2
5	Loaded 4-horse wagon	11	6	2	2
6	Unloaded 4-horse wagon	4	8	....	1
7	1-horse pleasure vehicle	115	132	37	38
8	2-horse pleasure vehicle	4	1	....	....
9	Rubber-tired horse vehicle	3	4	....	....
10	Saddle horse	17	13	4	3
11	Motor cycle	8	6	1	1
12	Excessively heavy vehicle[1]	4	4	....	1
13	Motor runabout	17	14	7	6
14	Motor touring car	82	93	29	29
15	Loaded motor dray	5	6	2	2
16	Unloaded motor dray	2	3	....	....

[1] Very heavy vehicles, such as carry ore, stone, timber, machinery, etc.

BRADLEY LANE, MONTGOMERY COUNTY, MD., 1915.

BITUMINOUS MACADAM, OIL-ASPHALT.

Description of the original construction of this experiment on Bradley Lane appeared in Bulletin No. 407, U. S. Department of Agriculture. The following report covers maintenance during the last year and the condition of the road in the spring of 1917.

At the time of construction in 1915 this experiment was top-dressed with limestone chips. Owing to the heavy traffic, all excess of this material was ground rapidly to powder and dissipated. In consequence, the wearing course stone became visible over the entire road, and in July, 1916, there was applied a surface treatment using a bituminous material represented by the analysis given in Table 46, and, instead of limestone chips, a hard, water-worn, $\frac{5}{8}$-inch river gravel. The quantities and costs appear in Table 47. The cost of this experiment to December 31, 1916, appears in Table 48. That the cost of maintenance was lower than that of surface treatment is explained by the omission of supervision and of a small distributed hauling charge from the total maintenance figures. The surface required no repairs of any kind and had displayed no weakness, except at one point in front of the first driveway on the south side near the east end of the road. Here a very small area of about 2 square feet showed a few web-like cracks in the spring of 1916. The surface at the time of last inspection was in perfect condition. No distinction has been apparent either in appearance or wear between the plain oil-asphalt macadam and the sand-oil-asphalt grouted macadam, and henceforth the entire road will be considered as a single experiment, reserving necessary comment only for the grouted section. A traffic census has been taken on this experiment, as on the others in Montgomery County, and the results appear in Table 49.

TABLE 46.—*Analysis of residual asphaltic petroleum*[1] *used in surface treatment of Bradley Lane.*

Specific gravity, 25°/25° C.	0.993
Specific viscosity, Engler, 100° C., 50 c. c.	13.5
Float test at 50° C., seconds	28
Loss at 163° C., 5 hours, 20 grams, per cent	13.71
Float test on residue, 50° C., seconds	151
Per cent of total bitumen insoluble in 86° B. naphtha	18.63
Per cent fixed carbon	11.25
Bitumen soluble in CS_2 (total bitumen), per cent	99.89
Organic matter insoluble, per cent	.08
Inorganic matter insoluble, per cent	.03
Total	100.00

TABLE 47.—*Materials and cost data for surface treatment in 1916.*

Area treated	square yards	6,788
Quantity of material per square yard:		
Bituminous material	gallons	0.195
Gravel	cubic yards	.0113
Cost per square yard (cents):		
Bituminous material		2.15
Gravel		2.90
Cleaning surface		.28
Hauling materials		.82
Applying bituminous materials		.80
Applying sand and gravel		.42
Supervision		.62
Total		7.99

TABLE 48.—*Surface maintenance costs of 1915 experiments, Bradley Lane, Montgomery County, Md., from Jan. 1 to Dec. 31, 1916.*

Experiment No.	Length of section.	Area.	Cost per square yard.			Maintenance cost per mile.
			Construction.	Maintenance.	Total.	
	Feet.	*Sq. yards.*	*Cents.*	*Cents.*	*Cents.*	
1	3,614	6,421	32.84	7.29	40.48	[2] $684.31
2	200	367	39.42			

TABLE 49.—*Volume and character of traffic on Bradley Lane, Jan. 1 to Dec. 30, 1916.*

		Twenty-four-hour period.			
		Maximum.		Average.	
		East bound.	West bound.	East bound.	West bound.
1	Loaded 1-horse wagon	11	15	6	7
2	Unloaded 2-horse wagon	12	13	5	4
3	Loaded 2-horse wagon	24	14	10	6
4	Unloaded 2-horse wagon	8	18	2	6
5	Loaded 4-horse wagon	3	3	1	1
6	Unloaded 4-horse wagon	1	1		
7	One-horse pleasure vehicle	11	8	3	4
8	Two-horse pleasure vehicle	1	2		
9	Rubber-tired horse vehicle	2	5		
10	Saddle horse	6	4	1	1
11	Motor cycle	37	42	9	10
12	Excessively heavy vehicle[3]	4	4	1	1
13	Motor runabout	95	88	27	33
14	Motor touring car	436	493	141	160
15	Loaded motor dray	35	41	18	24
16	Unloaded motor dray	10	13	4	3

---

[1] Viscous, sticky fluid.

[2] Width of surfacing taken as 16 feet.

[3] Very heavy vehicles, such as carry ore, stone, timber, machinery, etc.

WASHINGTON, D. C., 1915.

BITUMINOUS CONCRETE.

These experiments, constructed on the wing drives at either end of the main building of the United States Department of Agriculture, were described in Department Bulletin No. 407. At the time of inspection the surfaces were in excellent condition. They had had no repairs and required none. The only noticeable difference between the two experiments was the darker appearance and slightly closer texture of the surface constructed according to the District of Columbia specifications.

BUENA VISTA, FLA., 1915.

RESIDUAL ASPHALTIC PETROLEUM-CORALLINE ROCK.

This experiment was intended to serve as a check on section 6 of the Biscayne Drive experiments begun at Miami in 1913. The original report of the Buena Vista experiment appeared in Bulletin 407, U. S. Department of Agriculture. The following report is based on an inspection made December 22, 1916.

The traffic on this road has been very light and at the time of the inspection there was no evidence of wear on any portion. The surface showed some evidence of deterioration, however, from other causes. The following points were noted particularly:

(1) Uneven bleeding, due either to lack of uniformity in the original distribution of the bituminous material or to segregation of the different-sized particles of the aggregate. As a consequence, the surface presented a mottled appearance, and where sand had been added to the "fat" spots a surface mat had been formed, but because of the nature of the bituminous material this mat had not become bonded down firmly as a part of the road, but was easily loosened and scattered.

(2) A trench had been excavated across the road to receive a pipe leading to a pump house on the side of the road. After the trench was backfilled the road surface was tamped back in place and treated with oil of the kind used in the original construction. The surface over the trench was about three-fourths of an inch high, but otherwise satisfactory.

(3) About 50 feet of the south shoulder, near the pump house, was low and the surface showed a greater tendency to ravel here than on other portions of the road.

JUPITER, PALM BEACH COUNTY, FLA., 1915.

OIL-ASPHALT-SAND.

The original report of this experiment appeared in Bulletin No. 407, U. S. Department of Agriculture. The following report is based on an inspection made December 21, 1916. At that time the road had received no maintenance since its original construction in April, 1915, but was in fair condition. The surface had the general appearance of a road over sandy loam, except that the ruts of from 1½ to 2 inches were shallower than is usual with road surfaces of loam. The ruts in the natural sand road adjacent to the experiment were from 5 to 7 inches deep. Since the inspection of December 10, 1915, which was mentioned in the original report of this experiment, the coat of loose material on the surface had decreased in thickness to a minimum of about one-fourth of an inch and a maximum of about 1 inch. The path worn by horses in the center of the road was hardly noticeable. Instead of following the center line of the road, travel had followed a curved path, and near the center of the section the track was extremely close to the north edge of the surfacing. This no doubt was responsible for failure of the surfacing in several spots along the north rut, though some of the weak spots could not be explained in this way. The following is a list of the spots where partial or total failure has occurred, and which need immediate attention:

18 feet from east end of experiment, hole in center of road.
24 to 30 feet from east end of experiment, north one-half of road.
39 feet from the east end of experiment, center.
45 feet from east end of experiment, north rut.
66 feet from the east end of experiment, north rut.
71 feet from the east end of experiment, center and north rut.
84 feet from the east end of experiment, center.
100 feet from the east end of experiment, center and north rut.

The county officials at the time of inspection were preparing to treat the surface with asphaltic oil which was used extensively in construction of coralline-rock roads at the time. It was expected that such a surface treatment would check the disintegration at the points noted above, as well as prevent other defects from developing.

WEST PALM BEACH, FLA., 1915.

BITUMINOUS SAND.

In continuation of experiments Nos. 1 to 7 a section of sand-asphalt or bituminous sand surfacing was built in January, 1915, as experiment No. 8. Its construction is described in Bulletin 407, U. S. Department of Agriculture. This section was inspected on December 11, 1916, and its condition was as follows:

Experiment No. 8—Bituminous sand.—The surface showed waves at quite regular intervals. The sheet was intact, tough and very slightly calk-marked and pitted. No failure was apparent at any point and no difference in behavior of surface appearance was noticeable in the various parts of the experiment.

OCALA, FLA., 1915.

OIL-LIMESTONE, SAND-ASPHALT.

The original report of these experiments was published in Bulletin No. 407. U. S. Department of Agriculture. The following report is based upon an inspection made December 16, 1916, when, judging from the general condition of the road surface and shoulders, it was apparent that the experimental sections had received no maintenance since their construction.

Experiment No. 1—Limestone, residual asphaltic petroleum; penetration method.—The surface of this experiment appeared somewhat rougher than a year before, as the defects in construction showed more prominently owing to continued wear. At the same time this experiment demonstrates that with suitable care in construction a very satisfactory road can be built by the penetration method, using the soft Ocala limestone. At the time of inspection the section showed some areas which had pitted, owing to the excessive wear on large exposed fragments of stone or to picking out of individual pieces. In a few other places there had been apparently faulty distribution, owing in some instances to the wearing course having been bonded too tightly before the bituminous material was applied. Traffic is concentrated on a 9-foot strip and the wear has been quite uniform in the wheel tracks. Outside of the traveled way there was little evidence of wear. A seal coat over the entire section probably would prove of material benefit to the surface.

Experiment No. 2—Sand-oil asphalt.—This experiment was in practically the same condition as when completed in the summer of 1915. At the time of inspection there were some slight waves or depressions which appeared to have deepened little since construction, but at a few of the joints in the work slight depressions had formed. In a few places at the sides of the road, where there is no traffic, very slight cracks were apparent, but no cracks were evident where traffic exerts its action. In some places the limestone shoulders had worn considerably and needed immediate attention. So far as could be observed, the varying character of the base had caused no differences in the appearance of the surface and, as a whole the sand-asphalt experiment was in excellent condition.

LEMON CITY, FLA., 1914.

OILS, TAR PREPARATION, CALCIUM CHLORIDE-CORALLINE ROCK.

The original report of these experiments appeared in Bulletin No. 257, U. S. Department of Agriculture, and a subsequent report of an inspection in Bulletin No. 407, U. S. Department of Agriculture. The following report is based on an inspection made December 22, 1916:

In September, 1916, a treatment of crude oil was applied to the surface by the county road authorities. At the time of the inspection the surface was in good condition, except for one spot 115 feet from the north end of the sections. This spot is about 4 feet wide and 3 feet long and shows excess bituminous material and sand varying in thickness from three-quarters inch to 1¼ inches. The depressions noted in Bulletins Nos. 257 and 407 were not noticeable.

WEST PALM BEACH, FLA., 1914.

OIL, TAR, AND OIL-ASPHALT WITH CORALLINE ROCK.

These experimental sections were constructed about 2 miles south of West Palm Beach in May, 1914. The original report giving details of materials, methods and traffic, is published in Bulletin No. 257, U. S. Department of Agriculture, and supplementary report of conditions in Bulletin No. 407, U. S. Department of Agriculture.

The work was inspected on December 11, 1916, and the condition of the sections at that time was as follows:

Experiment No. 1—Residual asphaltic petroleum, 2.3 gallons, penetration method.—This section continued in very satisfactory condition. More of the seal coat appeared to be left on the first section, station 0+00 to station 0+50, than on the second section of the experiment. A small hole left open at approximately station 0+25 is now an irregular opening about 4½ by 4½ inches and the edges show no tendency to travel. Where the seal coat is gone, the stone showed a mosaic surface with the exposed aggregate worn flat. A wooden block, unintentionally left in the surface near the right side at approximate station 0+75, and another near the left side at approximate station 0+85, gave indication of very little wear. Seven small pits in the surface were counted near the north end of the experiment. Both sections of the experiment would take a seal coat of about one-tenth gallon per square yard to advantage.

Experiment No. 2—Refined coal tars, 1.3 gallons, penetration method.—A hard, rather than leathery, seal coat was intact on about 60 per cent of this experiment, but where breaks occurred there was a marked tendency to pit. A block left in the surface at approximate station 1+79, 2½ feet from the right-hand side, gave indication of very little wear.

Experiment No. 3—Refined coal tars, 1.2 gallons, penetration method.—This experiment presented a mosaic appearance and showed a pitted area approximately three times that noted at the inspection one year before. Apparently the tendency to pit was greater in areas where excessively large aggregate occurred and possibly also over pockets of very fine aggregate or dust. This latter might have been produced by the breaking up of large aggregate by traffic and not indicate fine material in the original construction. From approximate station 2+44 to the end of the experiment, a crude-oil seal coat was applied and the pitting somewhat reduced. At approximate station 3+40 a mark across the experiment, which appeared to be a heavy lapping was very noticeable and considerable pitting occurred on both sides of it.

Experiment No. 4—Residual asphaltic petroleum, 1.4 gallons, penetration method.—A noticeable line at approximate station 4+15 distinguishes the two parts of the first section of this experiment. The first part showed little tendency to pit where the mat was entirely gone and the sand mortar tended to wear away from around the stone. The mat was approximately 60 per cent intact on this section. On the second part of this section the mat was three-fourths gone and the aggregate exposed had a mosaic appearance. The sand mortar generally wore from around the stone. Section 2 of this experiment had a mat of a dead drab appearance more generally intact than that of section 1. The section showed a slight tendency to pit.

Experiment No. 5—Oil asphalt, 1.8 gallons, penetration method.—This section continued to show little change in appearance, except that the wear on the mat was marked by lateral streaks, which may indicate application lines. There was some tendency to pit where the mat was gone entirely. A plug hole at approximate station 6+14, about 4 feet from the right side, showed a very little tendency to ravel.

Experiment No. 6—Oil asphalt, 1.5 gallons, penetration method.—This experiment was in practically perfect condition, except for normal wear.

Experiment No. 7—Coralline rock, water-bound macadam.—This experiment showed considerable wear, approximating one-fourth inch in depth generally over the whole surface and 2 inches or more over most of the cross section for a distance of several feet from its junction with experiment No. 6.

MIAMI, FLA., 1913.

OIL-CORALLINE ROCK.

The original report of these experiments appeared in Bulletin No. 105, U. S. Department of Agriculture, and subsequent reports of several inspections in Bulletin Nos. 257 and 407. The following report is based on inspections made on April 24 and December 22, 1916. During April a sewer trench was cut through the experimental sections. An examination of the surfaces at that time showed section No. 3 to be in fairly good condition. Sections 4 and 5 were failing and in a very poor condition. The bituminous material showed a penetration of from three-fourths to 1 inch. Section 6 was in excellent condition and showed no signs of local failures or undue wear at any point. The bituminous material showed a penetration of from $1\frac{1}{2}$ to $1\frac{3}{4}$ inches.

In December Biscayne Drive and all the experimental sections received a top-dressing of light crude oil and coarse beach sand for the purpose of keeping down the dust during the tourist season. On December 22, when the road was last inspected, section 3 could hardly be distinguished from the surface-treated road adjacent, but it was evident that no serious break had occurred. Sections 4 and 5 were distinguishable by the numerous particles showing on the surface. Section 6 was in perfect condition, with the exception of the new surface over the sewer.

RÉSUMÉ OF PREVIOUS REPORTS.

These experiments are located on the Biscayne Drive about 2 miles north of Miami, Fla. The road connects Miami with Fort Lauderdale, Palm Beach, and other cities along the east coast, and is subjected to a fairly heavy mixed traffic. The purpose of these experiments was to obtain a satisfactory and permanent surface from the use in construction of a selected bituminous binder with the native coralline rock. Table 50 indicates the method of construction of the experimental sections and shows their condition at the time of several inspections since construction. The tabulation shown has been prepared from reports of inspections made by this office, published in Bulletins Nos. 105, 257, and 407, U. S. Department of Agriculture.

TABLE 50.—*Experiments at Miami, Fla.*

Section No.	Length.	Description of the original construction in 1913 (Bulletin No. 105, U. S. Department of Agriculture).	Condition Dec., 1913 (Bulletin No. 105, U. S. Department of Agriculture).	Condition Jan., 1915 (Bulletin No. 257, U. S. Department of Agriculture).	Condition Dec., 1915 (Bulletin No. 407, U. S. Department of Agriculture).
	Feet.				
1	96	*Semi-penetration method—cold, light oil.*—Old surface scarified, regraded, and left loose to a depth of 2 inches; cold, light oil applied at the rate of 0.9 gallon per square yard and allowed to soak in 2 hours before sanding and rolling; later rolling caused the surface to wave and crack; experiment gave small promise of success.	Very bad condition; section showed impracticability of employing penetration method on old coralline rock surface.	Worn out; will not be reported on again.	
2	453	*Surface treatment—cold, light oil.*—Old surface scarified, regraded, and waterbound; surface swept clean and cold, light oil applied at the rate of 0.5 gallon per square yard; after vigorous brooming the surface was sanded and rolled; construction hindered by rain.	Very poor condition..........	Worn out; will not be reported on again.	
3	200	*Penetration method—hot, heavy oil.*—Old surface regraded and a course of new unscreened stone spread to a depth of 2½ inches loose, this rolled very lightly; light rains during rolling caused surface to become slightly waterbound; hot oil applied at the rate of 0.6 gallon per square yard; surface sanded and rolled as in section 2.	Very satisfactory condition....	In fairly good condition, although it has worn somewhat rough; no breaks have occurred.	Practically in same condition as reported in inspection of Jan., 1915.
4	167	*Penetration method—cold, light oil.*—Similar to experiment No. 3, except that the stone course was heavily rolled; oil was applied at the rate of 0.7 gallon per square yard and allowed to stand 3 hours before sanding; practically all the oil was absorbed.	Practically the same as No. 3..	In fair condition; not as satisfactory as section 3; a group of worn places noted just north the middle of the section; some repairs made.	This section was deteriorating rapidly; binder had become brittle and rock was becoming loose over the whole surface.
5	239	*Penetration method—hot, heavy oil.*—Same as section 4, except that the stone course was reduced to a loose thickness of 1½ inches; from station 9+16 to station 10+87 sand was used for a top dressing and from 10+87 to 11+55 rock screenings were used.	Surface not as satisfactory as Nos. 3 and 4, although only three small holes have developed up to this time.	Very poor; apparently no economy in reducing depth of stone course; 17 worn depressions ranging from one-half to 2 square feet in area distributed throughout the section; had been patched with coralline rock.	Worn depression and holes last reported had increased greatly in size and number; bituminous material had lost its cohesive power and was crumbling rapidly.
6	107	*Penetration method—hot, heavy oil.*—Stone passed over a ⅜-inch screen and the portion retained was spread to a loose depth of 3 inches on the graded road; oil was applied at the rate of 1 gallon per square yard, which was enough to flush the voids; from station 11+55 to station 11+80 stone screenings were used as a top dressing; over the remainder sand was used.	In excellent condition; adjacent untreated road worn about 1 inch below surface elevation of this section.	In excellent condition; cross section well preserved and gave small evidence of wear.	This section was still in excellent condition and had required no repairs whatever.

ROCKVILLE PIKE, MONTGOMERY COUNTY, MD., 1913.

SURFACE TREATMENTS ON WATER-BOUND MACADAM.

The original report of these experiments was given in Bulletin No. 105, U. S. Department of Agriculture, and reports of inspections appear in Bulletins Nos. 257 and 407. The following report describes the condition of experiments on February 21, 1917.

Experiment No. 1—Refined coal tar, hot application.—This experiment continued to give trouble. Although the entire section was retreated in July, 1915, it became necessary to re-treat that part of the section, which was added in July, 1915, as described in Bulletin No. 407. Disintegration of the surface on this northern portion of the experiment had become so rapid that ordinary repairs were not adequate, and on October 18 to 21, 1916, the same bituminous material was used as in the original treatment of Experiment No. 1, an application of 0.33 gallon per square yard being made. On account of the lateness of the season and the possibility of low temperature, it was decided to broom the material in order to assure thorough contact with the old surface. The tar was delivered directly from the stills in tank wagons equipped with fire boxes and the material was distributed by gravity through a flat nozzle and thoroughly broomed. The material was applied uniformly and carefully in an effort to get the best possible results. The characteristics of a typical sample of the bituminous material are given in Table 51 and the cost data and quantities will be found in Table 53.

At the time of the inspection the entire experiment was in bad condition. South of Bradley Lane (the original experiment No. 1) the road was badly worn and had areas with large numbers of cup holes.

Considering the traffic on this section, the road is too narrow and the edges suffered severely on account of the frequent turning out of vehicles. North of Bradley Lane, which was re-treated as above described, the conditions were but little better. The road showed the same weaknesses and was requiring more bituminous patching than could be done in the season. It appeared probable that the entire section would require very heavy repairs and a general re-treatment as early in the spring as possible.

Experiment No. 2—Refined water-gas tar, cold application.—As contemplated in the last report, it became necessary to re-treat this section in July, 1916. Characteristics of a typical sample of the bituminous material used are given in Table 51, and the cost data and quantities in Table 53. The general condition of this experiment at the time of inspection was excellent, and generally the mat was hard, unbroken, and uniform.

TABLE 51.—*Analysis of refined tars used in re-treatment of experiments Nos. 1 and 2, Rockville Pike.*

	Experiment No. 1.		Experiment No. 2.	
Bituminous material	Coal tar refined		Water-gas tar refined.	
Characteristics	Viscous, sticky		Viscous, sticky.	
Specific gravity 25°/25° C.	1.209		1.140.	
Float test 32° C., seconds	135			
Specific viscosity, Engler 50 c. c., 50° C.			19.4.	
Per cent free carbon	13.56		2.91.	
	Per cent by volume.	Per cent by weight.	Per cent by volume.	Per cent by weight.
Distillation:				
First light oils (to 110° C.)			[3] 0.20	0.14
Second light oils (110° to 170° C.)			[3] .10	.08
Heavy oils (170° to 270° C.)	[1] 13.4	11.0	[2] 22.08	19.81
Heavy oils (270° to 300° C.)	[2] 7.8	6.5	12.04	10.82
Pitch residue	78.8	82.5	65.58	68.82
Total	100.0	100.0	100.0	99.67

[1] Solid. [2] Clear. [3] Cloudy.

Experiment No. 3—Asphaltic petroleum, cold application.—The action of this experiment is so well known that little description is necessary. Its conduct during the winters of 1915 and 1916 was thoroughly characteristic, and in June, 1916, it became necessary to re-treat as usual. The work was done by hand, as described in the last report, using the same bituminous material originally applied with torpedo sand as top-dressing. Table 52 shows the characteristics of the bituminous material and cost data will be found in Table 53.

All bottoms and all but the better drained slopes were thoroughly wet; one or two breaks had occurred near the top of the hill 600 feet from the south end of the experiment. The necessity for patching and re-treating during the following summer was evident.

TABLE 52.—*Analysis of asphaltic petroleums used in re-treatment of experiments Nos. 3 and 7, Rockville Pike.*

	Experiment No. 3.	Experiment No. 7.
Specific gravity 25°/25° C.	0.945	0.952
Flash point (° C.)	37	18
Burning point (° C.)	93	30
Specific viscosity, Engler, 50 c. c., 25° C.	97.5	90.9
Loss at 163° C., 5 hours, 20 grams, per cent	26.09	24.42
Float test on residue, 50° C., seconds	101	118
Per cent of total bitumen insoluble in 86° B. naphtha	14.67	10.47
Per cent fixed carbon	8.5	4.50
Bitumen soluble in CS_2 (total bitumen), per cent	99.85	99.92
Organic matter insoluble	.15	.05
Inorganic matter insoluble	.00	.03
Total	100.00	100.00

Experiment No. 4—Residual asphaltic petroleum, hot application.—Although section 4 had been patched heavily for over a year, it was decided in the summer to attempt to carry it through one more winter without general re-treatment. It was somewhat doubtful whether this was the best policy, for the section was acting very much as section 7 did during its second winter when re-treatment was postponed. There were a great number of breaks, small but prevailing generally over most of the section, showing more or less uniform failure of the mat. At some points a slight rutting had begun and made probable the necessity for very heavy patching and re-treatment early in the season.

Experiment No. 5—Residual asphaltic petroleum, hot application.—The condition of this experiment was comparable with that of experiment No. 4, although the disintegration did not appear to be quite so uniform. Though the surface was wet in all bottoms and poorly drained sections, there were larger areas almost intact. On the wet sections, the mat showed a tendency to break and form mud and considerable patching and it was thought a general re-treatment would be necessary the following summer.

TABLE 53.—*Materials and cost data for surface re-treatment, Rockville Pike, in 1916.*

Item.	Experiment No. 1, refined coal tar (hot).	Experiment No. 2, refined water-gas tar (cold).	Experiment No. 3, asphaltic petroleum (cold).	Experiment No. 7, asphaltic petroleum (cold).
Area treated...square yards..	4,825	7,475	12,333	11,148
Quantity of material per square yard:				
Bituminous material...gallons..	0.33+	0.157	0.154	0.16
Gravel...cubic yards..	.011+	.012+		
Sand...do...			.011	.01
Cost per square yard (cents):				
Bituminous material	3.00	1.71	1.65	1.92
Gravel	2.93	3.27		
Sand			2.86	2.76
Cleaning surface	.27	.07	.08	.05
Hauling materials		.41	.59	.82
Applying bituminous materials	.16	.29	.31	.22
Applying sand or gravel	.22	.26	.22	.30
Supervision	.22	.32	.24	.24
Total	6.80	6.33	5.95	6.31

TABLE 54.—*Surface maintenance cost of experiments on Rockville Pike to December 31, 1916.*

Experiment No.	Length.	Area.	Total cost per sq. yd. prior to Dec. 31, 1915.	Surface maintenance per sq. yd. during 1916.	Total cost of surface per sq. yd. to Dec. 31, 1916.	Surface maintenance per mile for year 1916.
	Feet.	*Sq. yds.*	*Cents.*	*Cents.*	*Cents.*	
1	9,060	15,100	27.70	5.26	32.96	$462.88
2	4,425	7,375	18.89	6.83	25.72	601.04
3	7,400	12,333	20.42	6.87	27.29	604.56
4	7,100	11,833	15.21	2.41	17.62	211.20
5	6,775	11,292	15.32	2.21	17.53	194.48
6	6,325	10,542	27.53	1.34	28.87	117.92
7	6,689	11,148	20.41	6.87	27.28	604.56

Experiment No. 6—Water-gas tar preparation, hot application.—The re-treatment of this section in November, 1915, put the surface in first-class condition and at the time of inspection it showed little wear, no breaks, and only a few small areas where moisture had permeated the mat. In general, the surface remained in fine condition.

Experiment No. 7—Asphaltic petroleum, cold application.—As contemplated in the last report, this experiment required re-treatment early in July, 1916. The characteristics of the bituminous material used are given in Table 52 and the quantities and cost data are given in Table 53. At the time of inspection the surface was in good condition for the season. It had not become so muddy as usual and the mat was much more uniform. Traffic census had been continued, regular counts having been taken for a 24-hour period every thirteenth day. A tabulation of the maximum and average of each class of traffic for the calendar year 1916 is given in Table 55. Traffic south of the census station is on experiment No. 1 only; that north of the station is on experiments Nos. 2 to 7, inclusive. Maintenance by patrolmen was continued during the year and Table 54 shows comparative cost data to December 31, 1916, for the various experiments included in this project.

TABLE 55.—*Volume and character of traffic on Rockville Pike.*

		Section 1.				Sections 2 to 7.			
		Maximum.		Average.		Maximum.		Average.	
		North bound.	South bound.	North bound.	South bound.	North bound.	South bound.	North bound.	South bound.
1	Loaded 1-horse wagon	30	18	18	9	22	11	10	5
2	Unloaded 1-horse wagon	17	31	7	14	8	17	4	7
3	Loaded 2-horse wagon	46	20	28	14	29	14	6	3
4	Unloaded 2-horse wagon	15	41	4	13	6	28	2	4
5	Loaded 4-horse wagon	5	6	1	1	5	5	....	1
6	Unloaded 4-horse wagon	4	3	1	....	4	1	....	....
7	1-horse pleasure vehicle	22	21	12	11	11	14	5	5
8	2-horse pleasure vehicle	2	1	....	....	1	1	....	....
9	Rubber-tired horse vehicle	2	2	....	....	1	1	....	....
10	Saddle horse	11	21	5	6	7	16	2	3
11	Motor cycle	74	71	17	19	57	61	15	15
12	Excessively heavy vehicle[1]	23	7	2	1	3	3	....	....
13	Motor runabout	105	110	50	50	82	87	34	33
14	Motor touring car	694	793	209	216	611	700	158	164
15	Loaded motor dray	66	55	40	32	41	46	23	23
16	Unloaded motor dray	16	42	5	13	12	12	3	5

[1] Very heavy vehicles, such as carry ore, stone, timber, machinery, etc.

WASHINGTON, D. C., 1912.

TAR PREPARATION AND OILS, SURFACE TREATMENT.

The original report of these experiments was published in Circular No. 99 of the Office of Public Roads, and inspection reports have appeared in Bulletins Nos. 105, 257, and 407, U. S. Department of Agriculture. The following report describes the maintenance during the year 1916 and the condition of the experiments March 28, 1917.

Section No. 1—Refined water-gas-tar preparation.—Although it seemed, in February, 1916, that this experiment probably would not require a re-treatment in the summer, wear developed uniformly until the mat became so thin that it was thought best to re-treat. This was done by hand in October, and the quantities and costs appear in Table 58. The same type of bituminous material was used as in the original surface treatment and the covering was torpedo sand. Analysis of a sample of the bituminous material is shown in Table 56. At the time of last inspection, March 28, 1917, this experiment had a mat generally intact and uniformly worn. Near the north end there were a few small breaks in the surface near the center of the roadway.

TABLE 56.—*Analysis of water-gas tar preparation* [1] *used in re-treatment of experiment No. 1, Washington, D. C.*

Specific gravity 25°/25° C.		1. 117
Specific viscosity, Engler, 50° C., 50 c. c.		18. 5
Per cent free carbon		2. 05
Distillation:	Per cent by volume.	Per cent by weight.
Water	0. 0	0. 0
First light oils (to 110° C.)	1. 0	. 7
Second light oils (110° to 170° C.)	. 5	. 3
Heavy oils (170° to 270° C.)	21. 0	19. 1
Heavy oils (270° to 300° C.)	[2] 10. 0	9. 6
Pitch residue	67. 5	70. 3
Total	100. 0	100. 0

During the autumn and winter of 1916 this experiment was subjected to a much heavier steel traffic than ever before, owing to construction operations on the department grounds. About 100 feet from the south end of the section a wide trench was cut through the roadway and was filled with cinders. A second trench, about 15 inches wide, had been cut through at a point 275 feet from the south end, and when filled the surface treatment had been patched. At the time of inspection the fill had settled somewhat and probably will have to be repaired. Other than the repairs over these trenches, the surface needed slight repairs and a light re-treatment during the summer.

Section No. 2—Asphaltic petroleum, surface treatment.—As contemplated at the time of last inspection report, this experiment required considerable patching and a re-treatment during the summer of 1916. The quantities and costs appear in Table 58, and the characteristics of the bituminous material used are given in Table 57. This was the same as used in the original treatment.

---

[1] Fairly viscous fluids.

[2] The 270° to 300° C. portion showed 5 per cent insoluble in dimethyl sulphate.

When inspected on March 27, 1917, this surface showed a larger degree of failure than ever before. The first 175 feet from the west end has a line of "cup" holes, generally confined to the middle third of the roadway. The mat was smooth and almost perfect over the next 100 feet, and there were only two small breaks. Then followed another section about 40 feet long spotted with the characteristic "cup" holes. The mat close to the "cup" holes was unbroken and although many of the holes were not over 3 or 4 inches in diameter and probably 90 per cent not over 8 inches across, many were an inch deep and some as much as 1½ inches. Along the last 200 feet at the east end of the section, seepage from the bank had done more damage than in any previous year. The "cup" holes continued along this part of the road, with an almost intact mat between them. This experiment showed the need of considerable repair and a general re-treatment in the summer.

Sections 3 and 4—Asphaltic petroleum.—Section 3 was repaired thoroughly in the summer of 1916 and given a re-treatment at the same time as section 4, and the same materials were used, so that the two sections are alike. Owing to the variation in past history, however, the three sections, 2, 3, and 4, will be continued separately so far as necessary. The re-treatment costs for section 3 appear in Table 58 and the analysis of the bituminous material is given in Table 57.

TABLE 57.—*Analysis of asphaltic petroleums used in re-treatment of experiments Nos. 2, 3, and 4, Washington, D. C.*

	Experiment No. 1.	Experiments Nos. 3 and 4.
Specific gravity 25°/25° C.	0.950	0.956
Flash point (° C.)	18	28
Burning point (° C.)	27	50
Specific viscosity, Engler 25° C., 50 c. c	108.6	187.5
Loss at 163° C., 5 hours, 20 grams...per cent..	22.45	28.23
Float test on residue, 50° C. seconds	119	188
Per cent of total bitumen insoluble in 86° B. naphtha	8.08	16.58
Fixed carbon...per cent..	5.49	9.04
Bitumen soluble in CS_2 (total bitumen)...per cent..	99.95	99.95
Organic matter insoluble...per cent..	.05	.05
Inorganic matter insoluble...per cent..	.00	.00
Total...per cent..	100.00	100.00

The mat on section 3 in March, 1917, was failing quite generally over all but 150 feet, where the drainage was best. Raveling of the macadam had started in a number of places and the effects of poor drainage, especially for the westerly 250 feet where the roadway is in cut, was more evident than at any time since construction. The south side had softened and rutted and many of the broken areas in the surface had spread until they had run together and a general disintegration of the surface appeared imminent. It appeared probable that reconstruction of the macadam would be necessary.

Section 4 was re-treated in October, 1916, and at the time of inspection was in almost perfect condition. A few small spots near the north end showed excessive wear, but otherwise the surface was uniform and intact. The quantities and costs appear in Table 58, and the characteristics of the bitumen, which was the same as used in original construction, were the same as of that used on section 3.

TABLE 58.—*Materials and cost data for surface re-treatment, Washington, D. C., in 1916.*

Item.	Experiment No. 1, refined water-gas tar preparation.	Experiment No. 2, asphaltic petroleum.	Experiment Nos. 3 and 4, asphaltic petroleum.
Area treated..........sq. yds..	1,318	1,129	2,041
Quantity of material per square yard:			
Bituminous material..........galls..	0.138	0.152	0.113
Sand..........cu. yds..	.0064	.0053	.0046
Cost per square yard (cents):			
Bituminous material..........	1.38	1.70	1.81
Sand..........	1.03	.86	.73
Cleaning surface..........	.05	.06	.13
Hauling materials..........	1.08	.27	.88
Applying bituminous materials..........	.42	.56	.56
Applying sand..........	.41	.49	.17
Supervision..........	.41	.48	.36
Total..........	4.78	4.42	4.64

CHEVY CHASE, MD., 1912.

BITUMINOUS CONCRETE, CEMENT CONCRETE, OIL CEMENT CONCRETE, VITRIFIED BRICK, BITUMINOUS SURFACE TREATMENTS ON CONCRETE.

The original reports of these experiments were begun in Circular No. 99 of the Office of Public Roads and completed in Bulletin No. 105, U. S. Department of Agriculture, and supplementary reports have been published in Bulletins Nos. 257 and 407, U. S. Department of Agriculture. The following report covers the condition of experiments on February 21, 1917.

Experiment No. 1—Bituminous concrete, Topeka specification.—This section continued in essentially the same condition as at last report. At points 15, 25, and 30 feet from the north end of the limestone section three cracks appeared, extending about one-half of the width of the surface on the gutter side. About 70 feet from the north end of the trap section, near the gutter, there were two breaks with an area of about 1 square foot each. In one of these the concrete base was exposed. The slight pitting noted in the last report had not increased.

Experiment No. 2—Bituminous concrete, District of Columbia specification.—This surface continued in the same condition as when last reported. Two cracks have appeared at 50 and 65 feet, respectively, from the north end on the track side and extend about two-thirds across the width of the surface. Slight pitting, due to the disintegration of exposed rock particles, was still noticeable, but there was no increase over that reported last year. The repairs made at the expansion joint, described in the last report, appear to have been adequate, as no further trouble has been experienced at this point.

Experiment No. 3—Cement concrete and oil cement concrete; surfaces treated with bituminous materials.—During the autumn the entire surface of experiment No. 3 received a carpet treatment with torpedo sand as a top-dressing. Sections A, B, G, and H were treated with a water-gas tar preparation, and sections C, D, E, and F with a residual asphaltic petroleum. Sections I and J received a carpet coat in two applications of one-half gallon of cold asphaltic petroleum. The first application was top-dressed with torpedo sand and allowed to stand 48 hours, after which the second application was made and additional top dressing applied. The material and cost data for these treatments are given in Table 59.

TABLE 59.—*Materials and cost data for surface retreatment in 1916, Experiment No. 3.*

Item.	Sections C, D,E,and F, residual asphaltic petroleum.	Sections A, B,G,and H, water-gas tar preparation.	Sections I and J, asphaltic petroleum.
Area treated......sq. yds..	1,725	1,840	667
Quantity of material per square yard:			
Bituminous material......galls..	0.275	0.306	0.499
Sand......cu. yds..	.0078	.0084	.0149
Cost per square yard (cents):			
Bituminous material......	3.00	4.14	5.94
Sand......	1.64	1.77	3.18
Cleaning surface......	.30	.12	.44
Applying bituminous materials......	.89	.87	.85
Applying sand......	.27	.25	.44
Supervision......	.23	.66	.80
Total......	6.33	7.81	11.65

Sections A and B: These sections were in almost perfect condition except for a distance of about 30 feet at the south end, which was treated in cold weather. Over this portion of the experiment there were quite a number of small scars, where the treatment had been removed by traffic.

Sections C, D, E, and F: This mat was noticeably heavier than that resulting from the application of water-gas tar and had a distinctly leathery texture. About 10 feet south of the E post there was one small break, the only one on the section. Slight calk marks were visible and quite generally distributed, and there appeared to be a tendency to push, but the wavy condition was barely noticeable.

Sections G and H: These sections showed no breaks, and the surface was smooth, but the wear near the center had exposed the concrete in a number of places.

TABLE 60.—*Analysis of water-gas tar preparation*[1] *used in surface treatment of concrete experiment.*

Specific gravity 25°/25° C.	1.155
Float test 32° C. (seconds), 321; 50° C. (seconds)	84
Per cent free carbon	2.22

Distillation:	Per cent by volume.	Per cent by weight.
Water	0.0	0.0
First light oils (to 110° C.)	.0	.0
Second light oils (110° to 170° C.)	.0	.0
Heavy oils (170° to 270° C.)	[2] 14.1	11.7
Heavy oils (270° to 300° C.)	[2] 8.9	7.4
Pitch	[3] 77.0	80.9
Total	100.0	100.0

Dimethyl sulphate test: Fraction:	Per cent by volume.	Per cent insoluble.
270° to 300° C	8.9	0.0
300° to 350° C	20.8	5.0
350° to 375° C	7.0	17.5

TABLE 61.—*Analysis of petroleum products used in surface treatment of concrete experiment.*

	Sections C, D, E, and F, residual asphaltic petroleum.	Sections I and J, asphaltic petroleum.
Specific gravity 25°/25° C	0.993	0.945
Flash point, °C		37
Burning point °C		93
Specific viscosity, Engler, 50 c. c	[1] 13.5	[2] 97.5
Float test at 50° C., seconds	28	
Loss at 163° C., 5 hours, 20 grams, per cent	13.71	26.09
Float test on residue 50° C., seconds	151	101
Per cent of total bitumen insoluble in 86° B. naphtha	18.63	14.67
Fixed carbon, per cent	11.25	8.5
Bitumen soluble in CS_2 (total bitumen), per cent	99.89	99.85
Organic matter insoluble, per cent	.08	.15
Inorganic matter insoluble, per cent	.03	.00
Total per cent	100.00	100.00

[1] At 100° C. [2] At 25° C-

Sections I and J: These sections were much like C to F and had a rubbery mat with few breaks, but a tendency to push. With cold and moisture the mat became somewhat mealy under traffic.

Experiments Nos. 4 and 5—Oil cement concrete; cement concrete.—There was less distinction apparent this year between experiments Nos. 4 and 5. The gravel aggregate showed a very material wear in No. 5. The limestone appeared to be worn more than the gravel, as evidenced by conditions along the eastern 4 feet of the surface and especially over the last 50 feet of experiment No. 4, south of the Columbia Club main entrance.

Experiment No. 6—Vitrified brick.—There has been no great difference in apparent wear between the several sections of this experiment.

---

[1] Very viscous. [2] Clear. [3] Hard, brittle.

Local failures occurred in sections K and L amounting in all to about 200 square feet. A profile has been run along both sides and along the center of the experiments indicating that there has been considerable settlement in the sections where local failures occurred. It was expected that repairs would be made in the spring by cutting out the depressed areas, keying the edges carefully and patching with brick similar to that used in the original work.

A traffic census has been taken on this road every 13 days for a 24-hour period. A tabulation of the maximum and average for each class of traffic for the calendar year 1916 is given in Table 62. The west side of the road carries south-bound traffic coming from the railroad and the east side carried north-bound traffic toward the railroad.

The total cost of each experiment to December 31, 1916, are shown in Tables 59 and 63.

TABLE 62.—*Volume and character of traffic on Kensington Road north and south of Bradley Lane, January 1 to December 30, 1916.*

		North.				South.			
		Maximum.		Average.		Maximum.		Average.	
		North bound.	South bound.	North bound.	South bound.	North bound.	South bound.	North bound.	South bound.
1	Loaded 1-horse wagon	7	30	3	14	18	17	10	8
2	Unloaded 1-horse wagon	9	20	3	9	9	16	5	7
3	Loaded 2-horse wagon	18	60	4	24	17	58	7	23
4	Unloaded 2-horse wagon	24	30	8	13	49	15	21	4
5	Loaded 4-horse wagon	1	3			3	2		
6	Unloaded 4-horse wagon	1	1			1	1		
7	One-horse pleasure vehicle	7	21	2	6	12	10	6	5
8	Two-horse pleasure vehicle	1	6			4	1		
9	Rubber-tired horse vehicle	5	3			5	3		
10	Saddle horse	10	11	3	2	15	10	3	3
11	Motor cycle	8	32	2	12	50	39	13	12
12	Excessively heavy vehicle [1]	5	5		1	6	7	1	1
13	Motor runabout	38	127	12	54	206	143	78	56
14	Motor touring car	295	635	83	264	858	711	386	293
15	Loaded motor dray	32	82	7	51	71	59	43	35
16	Unloaded motor dray	13	40	2	12	30	24	7	12

[1] Very heavy vehicles, such as carry ore, stone, timber, machinery, etc.

TABLE 63.—*Surface maintenance costs of 1912 experiments at Chevy Chase, Md., to December 31, 1916.*

Experiment No.	Area	Maintenance cost of experiments.			Total cost per square yard.		
		Total for experiments to Dec. 31, 1915.	1916.	Total.	Construction.	Maintenance.	Total.
	Sq. yds.				*Cents.*	*Cents.*	*Cents.*
1	1,498	$3.25		$3.25	186.62	0.22	186.84
2	1,400	7.66	$3.61	11.27	195.65	.80	196.45
3 [1]	4,178	3.57	338.76	342.33	[2] 154.95	8.19	163.14
4 [1]	1,744	20.50	17.66	38.16	[2] 150.25	2.19	152.44
5	3,013	22.73	8.28	31.01	[2] 142.29	1.03	143.32
6	2,055	1.77	1.59	3.36	258.21	.16	258.37

[1] In the progress report for 1915 the square yardage of experiment No. 4 included all oil-cement concrete. In October, 1916, sections G, H, I, and J were surface treated with bituminous materials and torpedo sand, restoring them to their original condition, and reducing the area of the oil cement concrete experiment to 1,744 square yards, as originally constructed. The area of experiment No. 3, which is now entirely surface-treated, is correspondingly increased to 4,178 square yards.

[2] Weighted average price for different sections.

CHEVY CHASE, MD., 1911.

BITUMINOUS CONSTRUCTION AND SURFACE TREATMENT.

The original reports of these experiments are given in Circulars Nos. 98 and 99, Office of Public Roads, and supplementary reports appear in Bulletins Nos. 105, 257, and 407, U. S. Department of Agriculture. The following report is based upon an inspection made February 21, 1917.

Section No. 1—Refined coal tar, penetration method.—Except at the narrow part of the section where traffic is much concentrated, this surface presented an excellent appearance. The wear has been even and a uniform, slightly mosaic condition prevails. At the curve the aggregate was exposed quite generally and a few shallow patches were needed. It appeared probable that a re-treatment of this portion with about 0.25 gallon per square yard would be required in the spring. The gutter on the west side of the section continued to give trouble and is responsible for a slight roughness at this place.

Section No. 2—Refined coal tar, modified Gladwell method.—The condition of this section continued satisfactory. The slight roughness along the gutter edge noted in the last inspection report had not increased, and except for a strip about 4 feet wide on the track side of the section, the surface was in practically perfect condition. The 4-foot strip required a little patching and would be benefited by a re-treatment.

Section No. 3—Fluxed native asphalt, penetration method.—The wear on this section, noted as being somewhat irregular last year, was much more even and the experiment is conspicuous on account of the uniform condition over the entire cross section. Only a few large stones were noticeable throughout the surface.

Section No. 4—Gilsonite oil-asphalt, penetration method.—The south end of this section did not require the heavy patching expected last season and continued in fair, but uneven, condition. The north end is heavily patched, especially along the track side. The mat continued in about the same condition as last year, but the surface was somewhat more uneven than that of section No. 3.

Section No. 5—Oil asphalt, penetration method.—The east and west parts of this experiment were much more nearly alike than in 1915. The east side has failed just as the west side did; heavy patching was needed. The west side continued intact as a result of the patching done, but both sides were rough and wavy.

Section No. 6—Oil asphalt, penetration method.—The east side of this experiment continued generally better than the west side. On the west side about 60 feet south of the Chevy Chase Club entrance there were two breaks through the surface, but the corrugations near the gutter had not increased and the surface otherwise was intact. It was much smoother than that of No. 5 throughout the traveled way.

Section No. 7, A and B—Oil asphalt, penetration method.—Section A continued distinctly more mosaic than B and required a little patching. Section B had the aggregate exposed in numerous spots along the east half and needed somewhat heavy patching in the spring, to go through the season. The west half toward the trolley tracks was much better and less moisture appeared through the surface than near the gutter.

Section No. 8—Refined water-gas tar preparation, surface treatment.—During the past summer experiment No. 8 was re-treated with the same type of bituminous material as used in previous treatments, and the section appeared to be better than is usual in winter. The recent treatment, however, wore away in small areas, exposing the smooth surface of earlier treatments beneath. There were no breaks in the surface, and the wear since the last re-treatment has been uniform with the surface, smooth and regular. This experiment indicated need of re-treatment in the summer. The cost of the re-treatment is given in table 65.

Section No. 9—Asphaltic petroleum, surface treatment; Section No. 10—Residual petroleum, surface treatment.—Section 9 was again re-treated during the past season. South of Kirke Street the east half of the section was wet and rough, but the rest of the section was better than is usual at the time of inspection, and presented a generally smooth surface, except for waviness on the east one-third. It seemed probable that the section would require another treatment. Table 64 gives an analysis of the bituminous materials used in re-treating sections Nos. 9 and 10, and the cost of re-treatments appear in Table 65.

Both ends of section No. 10 were rather better than usual at this season of the year but the middle one-third was bad, having developed the characteristic pot-holes at more or less regular intervals, owing apparently to the rhythmic impact of automobile traffic.

TABLE 64.—*Analysis of asphaltic petroleum used in retreatment of sections 9 and 10.*

Specific gravity 25°/25° C	0.952
Flash point (° C.)	18
Burning point (° C.)	30
Specific viscosity, Engler 50 c. c., 25° C	90.9
Loss at 163° C., 5 hours, 20 grams, per cent	24.42
Float test on residue, 50° C., seconds	118
Per cent of total bitumen insoluble in 86° B. naphtha	10.47
Per cent fixed carbon	4.50
Bitumen soluble in CS_2 (total bitumen)	99.92
Organic matter insoluble	.05
Inorganic matter insoluble	.03
Total	100.00

TABLE 65.—*Materials and cost data for surface re-treatment, Chevy Chase, Md., in 1916.*

Item.	Experiment No. 8, refined water-gas tar preparation.	Experiment No. 9, asphaltic petroleum.	Experiment No. 10, asphaltic petroleum.
Area treated .... square yards..	1,477	761	1,013
Quantity of material per square yard:			
Bituminous material .... gallons..	0.149	0.289	0.299
Gravel .... cubic yards..	....	.0138	.0114
Sand .... do.....	.0115	....	....
Cost per square yard (cents):			
Bituminous material........	1.85	3.47	3.59
Gravel........	....	3.53	2.91
Sand........	2.95	....	....
Cleaning surface........	.13	.03	.30
Hauling materials........	.41	.54	.49
Applying bituminous materials........	.55	.19	.23
Applying sand or gravel........	.25	.26	.36
Supervision........	.41	.74	1.02
Total........	6.55	8.76	8.90

TABLE 66.—*Surface maintenance costs of 1911 experiments at Chevy Chase, Md., to December 31, 1916.*

Experiment No.	Area.	Maintenance cost of experiments.			Total cost per square yard.		
		Total for experiments to Dec. 31, 1915.	1916	Total.	Construction.	Maintenance.	Total.
	Sq. yds.				*Cents.*	*Cents.*	*Cents.*
1........	1,581	$128.45	$4.23	$132.68	46.18	8.39	54.57
2........	705	16.14	4.55	20.69	64.42	2.93	67.35
3........	1,555	14.71	5.92	20.63	64.69	1.33	66.02
4........	1,555	46.77	10.32	57.09	57.18	3.67	60.85
5........	1,447	305.50	7.75	313.25	58.27	21.65	79.92
6........	1,555	35.62	8.85	44.47	68.22	2.86	71.08
7a........	131	6.58	2.90	103.19	59.96	10.54	66.03
7b........	848	93.71			54.80		
8........	1,477	130.80	117.05	247.85	39.59	16.78	56.38
9........	761	148.22	77.97	226.19	42.01	29.72	71.73
10........	1,013	437.84	131.16	569.00	44.31	56.17	100.48
11........	377	0.00	5.88	5.88	81.51	1.56	83.07

Section No 11—Native asphalt emulsion, macadam surfacing.—This section never has been re-treated and it has required no patching until the past season, when a few slight breaks were repaired. The mat was breaking rapidly and at date of inspection there were numerous places where the aggregate was exposed and four or five places where raveling was imminent, with moisture coming through about 60 per cent of the surface. It was probable that considerable patching and a reseal would be required in the spring.

Maintenance during 1916—In addition to the general re-treatments, as above described, the patrol system of maintenance was continued during the year. Table 66 presents the total cost of all maintenance, including the re-treatments shown in Table 65

A traffic census was taken every 13 days for a 24-hour period. The maximum and average of each class of traffic for the calendar year 1916 is shown in Table 62. Each side of the road carried traffic in one direction only.

JAMAICA, N. Y., 1911.

OIL-CEMENT CONCRETE, OIL-ASPHALT, TAR, AND FLUXED NATIVE ASPHALT.

The original report of these experiments was published in Circular No. 98, and reports of annual inspections and repairs are given in Circular 99, Office of Public Roads, and in Bulletins Nos. 105, 257, and 407, U. S. Department of Agriculture. The following report relates to the condition of the pavement on January 23, 1917:

Experiment No. 1—Oil-cement concrete.—In September, 1916, the old bituminous surface was loosened and removed. The concrete pavement for about 20 feet on each end of this section was broken up and rolled down with a steam roller to about 2 inches below the abutting grade. The whole area of this section was then covered with a 2-inch surfacing of Topeka asphaltic concrete.

Experiment No. 2—Cut-back oil-asphalt, mixing method.—The easterly 50 feet has been patched considerably and is in bad condition.

Experiment No. 3—Fluxed native asphalt, mixing method.—This section was in good condition except at places where cuts had been made for house connections and along the sides where the foundation had been poor. The waves in the surface on the north side at the east end had become 2 to 3 inches in depth and were lengthening westerly. They seemed to have originated from the waves in the adjoining section. The seal coat was wearing thin throughout the section.

Experiment No. 4—Refined coal tar, mixing method.—The tar seal coat on the westerly half was worn nearly off. The whole surface showed waviness, especially along the north edge for a width of 5 feet from station 8 to station 9 and for a width of 10 feet on the south side from station 8+45 to station 9+50 where the surface has disintegrated in places to a depth of from 1 to 3 inches. The asphalt seal coat on the easterly half was becoming thin and worn through in several places. Several shallow potholes had formed along the north side from station 9+50 to station 9+65 and the disintegration had extended deeper on the south side from station 10+60 to station 10+80. In September, 1916, the surface east of a house connection near station 10+80 was replaced with a 2-inch surface of Topeka asphaltic concrete.

Experiment No. 5—Cut-back oil-asphalt, mixing method.—In September, 1916, the surface of this section, except the easterly 100 feet, was rebuilt with Topeka asphaltic concrete. The surface on the easterly 100 feet was in fair condition, except along the sides and the center from station 13+25 to station 13+40, where the seal coat had worn through and several potholes had formed.

Experiment No. 6—Oil-asphalt, penetration method.—In the spring of 1916 two small potholes about 7 feet north of the center at stations 13+97 and 14+13, and two small potholes at the junction of experiments Nos. 6 and 7 were patched with broken stone and asphaltic cement. No other repairs were made on the section during the year. The seal coat was worn through in a number of places and potholes were developing on the north side at stations 15+40 and 15+45, where the foundation had been poor. From station 13+94 to station 14+38 the surface was disintegrated slightly.

Experiment No. 7—Refined coal tar, penetration method.—Potholes have formed in the surface from station 15+57 to station 16+95. The south edge from station 16 to station 17 was in poor condition. The seal coat was becoming very thin. This section was less wavy than any of the other sections and, on the whole, was in good condition.

Experiment No. 8—Fluxed native asphalt, penetration method.—The slight waviness of the surface was a little more pronounced than at the previous inspection. The small pothole at station 17+60 had disappeared but a depression still was noticeable. On the whole this section was in very good condition.

Experiment No. 9—Oil asphalt, penetration method.—The surface was raveled to a depth of about one-half inch or more in a number of places scattered throughout the section. At the easterly end the surface abutting the wood-block pavement was particularly bad in this respect. This probably was due to a slight difference in grade elevation for the two surfaces.

RÉSUMÉ OF PREVIOUS REPORTS.

OIL-CEMENT CONCRETE, OIL ASPHALT, TAR, AND FLUXED NATIVE ASPHALT.

This experimental road, 25 feet wide, was built in August and September, 1911. The work consisted in resurfacing a 2,000-foot length of badly worn, water-bound macadam pavement on Hillside Avenue. Before the experimental work was begun the old macadam surface was scarified and rebuilt to a crown of three-eighths inch per foot by addition of material and rolling. On this macadam as foundation nine experimental surfaces were laid—one oil-cement concrete pavement, four bituminous concrete pavements, and four bituminous macadam pavements. The aggregates used in all the experiments was clean, crushed trap rock, screened according to the following grades.

Screenings—Crusher run passing a ⅝-inch circular opening including dust of fracture; ¾-*inch stone*, passing 1¼-inch circular opening and retained on ⅝-inch opening; 1½-*inch stone*, passing 2¼-inch circular opening and retained on 1¼-inch opening; ⅜-*inch stone* screenings from which dust had been removed.

Traffic census for 11 days in 1911 showed a maximum of 2,794 vehicles per day of 24 hours, a minimum of 655 vehicles per day of 24 hours, an average of 1,493 vehicles per day of 24 hours.

Table 67 indicates the method of construction of the experimental sections and shows their condition at the time of several inspections since construction. The tabulation shown has been prepared from detail reports of inspection and published in Circulars Nos. 98 and 99, Office of Public Roads, and in Bulletins Nos. 105, 257, and 407, U. S. Department of Agriculture.

TABLE 67.—*Condition record of experimental road sections at Jamaica, N. Y.*

Section No.	Length.	Description of original construction, 1911 (Office of Public Roads Circular No. 98).	Condition May 1912 (Office of Public Roads Circular No. 99).	Condition June, 1913 (U. S. Dept. Agr. Bul. No. 105).	Condition Jan., 1915 (U. S. Dept. Agr. Bul. No. 257).	Condition Jan., 1916 (U. S. Dept. Agr. Bul. No. 407).
	Feet.					
1	173	*Oil-cement concrete.*—Proportion by volume, 1 Portland cement, 2 sand, 4 crushed trap rock, and residual oil to the amount of 10 per cent by weight of the cement; coarse aggregate $\frac{3}{4}$-inch maximum to $\frac{1}{4}$-inch minimum; one layer 4 inches thick, with addition of trap-rock screenings on the tamped surface for the first 12.5 feet; the remaining surface covered with mixture made in the proportion of 2 bags cement, 2.5 feet sand, 7.5 screenings, and 8 quarts oil.	Surface had small worn areas ranging from a few square inches to 2 or 3 square feet; entire concrete surface coated with a bituminous seal coat, using different types of bitumen; also worn places repaired with bitumen and stone chips.	The various carpet coats had worn off, except about 75 per cent of the refined coal-tar portion; section given a seal coat of different bituminous material; many deep depressions which had formed were repaired.	Repair of bare spot had been made in 1914, surface in very good condition, except for about 20 bare spots.	Bituminous surface treatment worn away in many places; concrete worn and potted in places.
2	299	*Cut-back oil-asphalt, mixing method.*—Compacted depth 2 inches; proportion—7.5 cubic feet, $\frac{3}{4}$-inch stone to 5.5 gallons of bitumen; bitumen heated to 240° F.; stone dried; surface finished with seal coat and $\frac{3}{8}$-inch stone; seal coat bitumen applied by means of distributer; rainy weather during construction retarded progress.	Surface in good condition, except at station 4+94; depression due to a yielding of the foundation; this place was repaired; from station 1+98 to 4+50 the surface was rough and wavy, but unbroken; this part had not been repaired.	From station 1+98 to station 4+50, scarified and rolled; new seal coat of refined coal tar applied at the rate of 0.53 gallons per square yard; remaining section was slightly wavy in surface; no repair made.	In May, 1914, entire surface scarified to depth of 3 inches; about one-third of bituminous material raked off; surface rolled and covered with $\frac{3}{4}$-inch stone; rolled, covered with thin layer of chips, and opened to traffic.	Section entirely scarified in October, 1915, except for the easterly 50 feet; shaped and rolled and surfaced with 2-inch asphaltic concrete prepared according to the Topeka specifications; easterly 50 feet in fair condition.
3	304	*Fluxed native asphalt, mixing method.*—Other features same as in section No. 2, except bitumen heated to 340° F. Also seal coat applied by means of hand pouring pots; bad weather during construction.	Excellent condition, except at station 5+00 a slight depression due to wear; repaired by applying an oil-asphalt seal coat.	Slightly wavy; otherwise in excellent condition.	All in good condition, except in places where house sewer connections were made.	Same as when last inspected.
4	298	*Refined coal tar, mixing method.*—Proportion, 10 cubic feet stone to 7 gallons bitumen; in the seal coat, coal tar was used for the first 150 feet, oil-asphalt for the remainder; other features as shown in section No. 3.	Seal coat of oil-asphalt in good condition; seal coat of refined coal tar entirely worn off; new seal coat of light coal tar at the rate of 0.28 gallon per square yard applied from station 8+00 to station 8+70 and from station 8+70 to station 9+50; seal coat of tar-asphalt preparation applied.	Slightly wavy; otherwise in excellent condition.	Section in excellent condition, except for wavy surface in places and for a few small spots where seal coat is worn off.	Wavy on sides; center in good condition; on south side surface crumbling where seal coat has been worn off.

TABLE 67.—*Condition record of experimental road sections at Jamaica, N. Y.*—Continued.

Section No.	Length.	Description of original construction, 1911 (Office of Public Roads Circular No. 98).	Condition May 1912 (Office of Public Roads Circular No. 99).	Condition June, 1913 (U. S. Dept. Agr. Bul. No. 105).	Condition Jan., 1915 (U. S. Dept. Agr. Bul. No. 257).	Condition Jan., 1916 (U. S. Dept. Agr. Bul. No. 407).
	Feet.					
5	296	*Cut-back oil-asphalt, mixing method.*—Same as in section No. 2, excepting proportion was changed so as to use 10 cubic feet of stone to 7 gallons bitumen, the bitumen was a similar type of material, but was obtained from another manufacturer, and seal coat was applied by means of pouring pots.	In good condition, except for two holes at station 13+37, these filled with Topeka asphalt paving mixture.	General surface good; several holes worn through surface; repaired.	Section is wavy; seal coat is wearing off and pot holes are forming.	West end badly worn; should be rebuilt, other part less worn, but also in need of repair.
6	156	*Oil-asphalt, penetration method.*—A single course of $1\frac{1}{2}$-inch stone spread to a loose depth of 3 inches; rolling followed by an application of oil-asphalt at the rate of $1\frac{1}{2}$ gallons per square yard; surface covered with $\frac{3}{8}$-inch stone chips and rolled; a seal coat with the penetration material and $\frac{3}{8}$-inch stone chips used on eastern one-half; cut-back oil asphalt used for seal coat on western half.	In good condition, except for damage done by steel-tired trucks; damage repaired.	In excellent condition; two grades of oil asphalt used for seal coat; apparent that the heavy is the better.	Section in good condition, except that seal coat is wearing off.	Same condition as at time of last inspection, except sides are becoming wavy.
7	150	*Refined coal tar, penetration method.*—Bitumen applied at temperature of 260 to 270° F., with distributor; other features as shown in section No. 6.	In good condition, except for slight break in seal coat due to trucks described in No. 6; damage repaired with tar asphalt and sand.	General surface good; several holes worn through surface; repaired.	Seal coat wearing off on edges; a few pot holes are forming; otherwise in good condition.	Good condition, except for a strip 5 feet wide along south side, where surface is disintegrating.
8	150	*Fluxed native asphalt, penetration method.*—As used in section No. 3; temperature 330° F.; other features as shown in section 7, including use of distributor.	Surface quite soft in early summer; damaged by trucks previously mentioned; damage repaired by tar asphalt and sand.	In good condition..........	Slight waviness developing over entire surface.	Same as at time of last inspection, except for one hole which is developing.
9	150	*Oil-asphalt, penetration method.*—Other features as shown in section No. 8..................	Seal coat had been picked up in a few places by the steel-tired trucks; this damage was repaired; the surface was depressed at station 19+25 over on old sewer trench; this was repaired.	In good condition, except for one hole; this repaired.	Seal coat worn off in places; few pot holes developed; otherwise in good condition.	Same as at previous inspection, except that seal coat is wearing off in one place.

AMES, IOWA, 1910.

OIL-ASPHALT GRAVEL.

Résumé of Previous Reports.

This experimental road was built in September, 1910. The work consisted in resurfacing a 300-foot section of gravel road in the grounds of the Iowa State Agricultural College. The old gravel road had a thickness of 6 inches and was in good condition when the work was begun. A portion of the traffic was automobile. Table 68 shows the condition of the experiment at various times since its construction. The results shown have been taken from the reports of inspection made by this office, published in Circulars Nos. 94, 98, and 99, Office of Public Roads, and in Bulletins 105, 257, and 407, U. S. Department of Agriculture.

TABLE 68.—*Experiments at Ames, Iowa.*

Length	Description of original construction, 1910 (Office of Public Roads Circular 94).	Condition November, 1911 (Office of Public Roads Circular No. 98).	Condition October, 1912 (Office of Public Roads Circular No. 99).	Condition January, 1914 (Bulletin No. 105, U. S. Dept. Agr.).	Condition December, 1914 (Bulletin No. 257, U. S. Dept. Agr.).	Condition December, 1915 (Bulletin No. 407, U. S. Dept. Agr.).
Feet. 300	*Oil-asphalt gravel.*—Oil-asphalt at 300° F., applied to a loose gravel surface at the rate of 1½ gallons per square yard; when asphalt had become cold surface was saturated thoroughly with water and harrowed; surface rolled when it had dried out; width of the surface 27 feet; crown, one-half inch to 1 foot.	Surface uniform throughout, about 1 inch of mud carried on it from adjoining road.	More travel on east side; this has the smoothest surface; hole dug in center of road shows bitumen 3 inches deep below surface.	Good condition, two or three depressions; surface resembles a brown layer of packed gravel and old bituminous material which is friable.	Generally in good condition; surface has been reshaped and treated with a light oil; effect not yet apparent.	Light oil again applied in June, but unsuccessful; in October heavy asphalt oil applied to the traveled portion at rate of one-half gallon to square yard; in good condition at time of this inspection.

KNOXVILLE, TENN., 1910.

TAR AND OIL PREPARATIONS.

Résumé of Previous Reports.

This experimental road was built in the summer of 1910. The work consisted in resurfacing a section of the Rutledge Pike, an old, badly worn, water-bound macadam. Before the experimental work was begun the old macadam surface was loosened and reshaped. Crushed limestone ranging from 2 inches to three-quarter inch in diameter was spread over the road to a depth of 2 inches, and rolled. A crown of one-half inch to a foot was used for both the foundation and the surface. On this macadam as foundation, three experimental surfaces, 20 feet in width, were laid, using bituminous materials by the penetration method. A very hard limestone, known locally as iron limestone, was used in the wearing course of all the experiments. The following table indicates the method of construction and shows the condition of the experimental sections at the time of the several inspections. The tabulation has been prepared from reports made by this office and published in Circulars Nos. 94, 98, and 99, Office of Public Roads, and in Bulletins Nos. 105, 257, and 407, U. S. Department of Agriculture.

TABLE 69.—*Condition of experiments at Knoxville, Tenn.*

Section No.	Length.	Description of original construction in 1910 (Office of Public Roads Circular No. 94).	Condition November, 1911 (Office of Public Roads Circular No. 98).	Condition January, 1913 (Office of Public Roads Circular No. 99).	Condition December, 1913 (Bulletin No. 105, U. S. Dept. Agr.).	Condition November, 1914 (Bulletin No. 257, U. S. Dept. Agr.).	Condition December, 1915 (Bulletin No. 407, U. S. Dept. Agr.).
1	*Feet.* 217	*Refined coal tar, penetration method—Wearing course.*—Hard, clean limestone, ranging in size from 2 inches to three-fourths inch; Loose depth 4 inches; rolled until firm; binder at a temperature of 250° to 300° F., applied at the rate of $1\frac{1}{2}$ gallons per square yard; $\frac{1}{2}$-inch size screenings applied; surface rolled; seal coat of penetration material at rate of one-half gallon per square yard, followed by addition of screenings.	Seal coat worn off; otherwise in good condition; surface hard and smooth; harder than No. 3.	Surface raveled and numerous depressions; section will be resurfaced in the spring.	Section was not resurfaced, as was expected, and now has appearance of a plain macadam.	Section worn out; serves no further purpose as an experiment.	Failed completely.
2	590	*Refined tar preparation, penetration method.*—Constructed in same manner as No. 1, with exception that a different binder was used; the binder was a refined mixture of coal tar and water-gas tar.	Same condition as section No. 1, except not quite such a Mosaic appearance and seal coat not worn to same extent.	Eastern half of section in good condition; western half has several raveled areas.	About one-half of seal coat worn off; surface uneven; surface broken for several water mains; not properly repaired.	Surface covered with holes and depressions; this section should be reconstructed.	Do.
3	173	*Asphalt, penetration method.*—Constructed in same manner as No. 1, with exception that an oil-asphalt was used for a binder.	In good condition; surface softer than in sections Nos. 1 and 2 and has the appearance of sheet asphalt; depressions at the east end of the section.	Practically same condition as at time of last inspection.	Surface smooth and hard; in very good condition.	Except for a few depressions on west side, this section is in excellent condition.	In good condition.

YOUNGSTOWN, OHIO, 1909.

SLAG, SLAG AND LIME, SLAG AND WASTE SULPHITE LIQUOR PREPARATION, AND SLAG AND TAR.

The original report describing these experiments was published in Office of Public Roads Circular No. 92, and subsequent reports of annual inspections in Circulars Nos. 94, 98, and 99, and in Bulletins Nos. 105, 257, and 407, U. S. Department of Agriculture. The following report describes the condition of the various experiments on December 4, 1916, and furnishes a brief résumé of previous reports. The experiments are discussed in the order of their section numbers, beginning at Mahoning Avenue.

Section No. 1, blast-furnace slag—The condition of this section was unchanged materially since the inspection in December, 1915, except that the middle of the road was no longer pulverized, and pronounced depressions about 2 inches deep have developed in the wheel tracks at about 150 feet and 175 feet from the north end. A hole dug about 200 feet from the north end of the section showed the depth of slag to be about 8 inches. A laboratory examination of a sample of this slag showed (1) that the slag particles were carbonated on the surface and (2) a cementing value of 55.

Section No. 2, blast-furnace slag and lime—The south one-half of this section showed two wide, shallow ruts, with a slight accumulation of fine loose material along both edges of the road, and over this part of the section the crown of the surface had disappeared almost entirely. The remainder of the section had not changed materially in appearance since the inspection of December, 1915, except that the ruts had become slightly more pronounced and a few of the foundation stones were showing in the surface. Holes dug at 125 feet from the north end and 30 feet from the south end showed the depth of slag to be 6½ inches. A sample of this slag showed (1) that the slag particles were carbonated on the surface and (2) a cementing value of 115.

Section No. 3, blast-furnace slag and waste sulphite liquor preparation—The north end of this section, for a distance of 100 feet, was resurfaced with slag sand in the fall of 1916. The next 100 feet showed a rather loose surface with two broad, shallow ruts, though the depression along the center of the road noted in December, 1915, had almost disappeared. The remainder of the section (300 feet) was worn uniformly and in good shape, except for depressions in the ruts near the middle of the section, which cover an area of about 2 square yards, and the west edge of the road had been partially destroyed to a width of about 1 foot for a distance of about 100 feet from the south end. The latter damage was caused by failure to maintain the shoulders in proper shape. The south end of the section was worn down about 2½ inches below the surface of section 4, where a bituminous binder was used.

Holes were dug at 225 feet from the north end and 175 feet from the south end of the section and showed the depth of the slag to be about 6½ inches. A sample of the slag showed (1) that the slag particles were carbonated on the surface, (2) that the pores of the slag contained calcium hydrate crystals, (3) a cementing value of 63.

Section No. 4, blast-furnace slag and refined coke-oven tar—The south 50 feet remained in good condition, except that the surface was slightly wavy. The remainder of the section, which was reported as having failed at the time of the inspection of December, 1915, had been covered over with slag sand, and is no longer of experimental value. A sample of the new slag sand showed a cementing value of 67.

Section No. 5, blast-furnace slag—The south 90 feet of this section was in uniformly good shape. The remainder of the section, through the cut, was worn into ruts and showed an accumulation of fine material on the surface. The ruts noted at the time of the inspection of December, 1915, 165 feet and 135 feet, respectively, from the south end, had increased in depth to about 3 inches. For the rest of the distance the ruts were broad and shallow. The north end of the section still was about 1½ inches below the surface of section 4.

Section No. 6, blast-furnace slag—This section had not changed in appearance since the inspection of December, 1915, except that an accumulation of fine material had collected along the east edge of the road. A hole dug about 150 feet from the south end of the section showed the depth of the slag to be about 9½ inches. A sample of the slag showed (1) that the particles of slag were carbonated on the surface and (2) a cementing value of 45.

Section No. 7, blast-furnace slag and open-hearth slag—The north one-third showed little evidence of wear and the surface was firm and well bonded. The south one-third showed considerable wear along the wheel tracks, but the top course did not appear to have worn through, and the surface still was firm and well bonded. The depression over the culvert near the south end had flattened out, due to the wearing action of traffic, but had not been repaired. The middle one-third of the section was resurfaced with slag sand in the fall of 1916, and probably will not be of any further service as an experiment. It was evident that the surface had become rather rough and badly rutted before the slag sand was applied.

Holes dug at 50 feet and 100 feet from the south end showed the depth of the slag to be about 9 inches. A sample of the slag showed a cementing value of 65, carbonated surfaces, and practically no evidence of the open-hearth screenings used in the original construction.

TABLE 70.—*Experiments at Youngstown, Ohio.*

Section No.	Length.	Description of original construction.	Condition Jan. 27, 1911, just after thaw.	Condition Dec. 10, 1911.	Condition Dec. 11, 1912.	Condition Sept. 1, 1913.	Condition Oct. 26, 1914.	Condition Dec. 3, 1915.
	Feet.							
1	500	Regular macadam method; first course, 9 inches loose; size of particles, 1½ to 3½ inches; second course, 4 inches at center, 2½ inches at edge, loose; finished with screenings, water, and rolling.	Surface in good condition and free from raveled spots.	Surface smooth in wheel tracks, loosened in middle of road; better than section No. 5, but not so good as section No. 6.	Surface in excellent condition, except north 50 feet, which had been scarified shortly before inspection; slight evidence of wheel ruts entirely due to wear of traffic.	Surface firm and well bonded and crown intact; foundation slag only very slightly in evidence.	Same as preceding report, except that well-defined shallow ruts have developed and there are three depressions where binder has disappeared.	Same as preceding report, except middle of road slightly more worn and pulverized.
2	500	Same as section No. 1, except 5 per cent of powdered quicklime was mixed with screenings by hand; bonded very quickly on being sprinkled and rolled.	Surface somewhat raveled and scarcely better than sections 5 and 6; not so good as section 1; reported to have been better in summer.	Substantially the same as section No. 1.	In good condition, except for slight evidence of ruts as in section No. 1.	Same as section No. 1, except foundation slag slightly more in evidence and slight ruts in traveled way.	Same as preceding report.	Same as section No. 1, except ruts slightly deeper and surface slightly more worn.
3	500	Same as in section No. 1, except waste sulphite liquor used in bonding top course and screenings at rate of 1 gallon per square yard; road cracked and blistered on being opened to traffic and was rebonded, using water.	Better than section 1, but not so well bonded as section No. 7.	Good appearance and slightly better bonded than section No. 6.	Surface covered with thin coating of clay, due to grading operation on west side of road; appearance otherwise very good, and there is no evidence of raveling.	Same as section No. 2.	Same as section No. 2, except that south half of section shows slightly less evidence of wear.	North one-half same as section No. 2; south one-half better preserved.
4	300	First course same as section No. 1; second course, 4 inches deep, loose, 3 parts slag, 1½ inches to ¾ inch, 1 part slag, ⅜ inch to dust, 6 per cent coke-oven tar, all heated and hand mixed; seal coat, ¼ gallon tar to square yard and screenings; total tar 1½ gallons to square yard.	Surface perfectly bonded with mosaic appearance; fresh fill had settled, causing irregularities in surface, but no damage to bond.	Surface in excellent shape, except for several loose spots at 80 and 100 feet from north end, where fill has settled.	North and south thirds present good appearance; middle third, on fill, has settled unevenly and disintegration is following; apparent shortage of tar at some points.	Shows from 1½ to 2 inches less wear than adjoining sections; evidence of disintegration has not increased since last report.	Same as 1912 inspection, except that evidences of failure have increased, especially in middle third.	South 50 feet still intact and presents smooth, well-bonded surface; rest has failed because of foundation settlement.

TABLE 70.—*Experiments at Youngstown, Ohio*—Continued.

Section No.	Length.	Description of original construction.	Condition Jan. 27, 1911, just after thaw.	Condition Dec. 10, 1911.	Condition Dec. 11, 1912.	Condition Sept. 1, 1913.	Condition Oct. 26, 1914.	Condition Dec. 3, 1915.
	Feet.							
5	300	Single course, 12 inches at center, 9 inches at edge, loose; slag ¾ inch to 3½ inches in size; surface finished with screenings, water, and rolling; much rolling necessary.	Center of roadway badly raveled; soft spot in center of road near middle of section.	Surface smooth in wheel tracks, loosened in middle of road; reported to have been practically dustless during preceding summer.	Ruts more apparent than on other sections, but no evidence of raveling; section has worn down about 1½ inches below section No. 4 where they join.	Slightly dusty; large stones showing in surface; shallow ruts in traveled way.	North two-thirds in cut appears to have been damaged by softening of foundation, due to lack of subdrainage, and is worse rutted than any other of the sections; south one-third in good condition.	North two-thirds same as preceding report; south one-third has developed ruts and two depressions.
6	325	First course, 9 inches deep, loose, slag 3½ inches to dust; second course, 6 inches at center, 4 inches at edge, slag 3½ inches to ¾ inch; rolled and finished same as section No. 1.	Center of road badly raveled; slightly better than section No. 5, but not so good as section No. 1.	Similar to Nos. 1 and 5, except slightly better.	In fair condition, except for slight ruts; surface covered with film of dust, but no evidence of raveling.	Same as section No. 5, except larger stones are showing in surface, and there are several shallow worn places.	Same as preceding report, except that wear is more evident in ruts, as well as other depressions.	Same as preceding report.
7	325	Same as section No. 6, except screenings were of open-hearth slag, ¼ inch to dust; spread 1½ inches deep, loose; when puddled and rolled a firm surface was quickly produced.	Surface very firm and well bonded; few small holes caused by soft particles of slag; condition second only to section No. 4.	Slight unevenness for 100 feet at north end over fill; otherwise same as preceding report; second only to section No. 4.	Fair condition, except for slight ruts and film of dust which produces mud when wet; slight settlement over culvert.	Same general appearance as sections Nos. 5 and 6; settlement over culvert has increased.	Surface swept during preceding summer has not raveled; ruts 2 and 3 inches deep in places; depression over culvert increased.	Surface firm and well bonded and harder than any other section, except south 50 feet of section No. 4.

These experiments have now been under way for about seven years, and the salient features of the records are summarized below for convenience.

The total length of the experimental road is 2,750 feet, and the width of the slag surface 14 feet. The blast-furnace slag was obtained from the Youngstown plant of the Carnegie Steel Co., and had weathered on the dump for some time. The slag was selected with care and was screened to the sizes indicated for the different sections. The open-hearth slag was obtained from the ordinary basic open-hearth process and was ground to the size indicated. The tar was a refined coke-oven tar, and the waste sulphite liquor was a concentrated form of the ordinary by-product in the manufacture of wood pulp. The traffic over the road is only moderate, but no actual counts have been taken.

GARDEN CITY, DODGE CITY, BUCKLIN, AND FORD, KANSAS, 1908.

SAND-CLAY.

The original report of these experiments appeared in Circular No. 90, and reports of subsequent inspections in Circulars Nos. 92, 94, 98, and 99, Office of Public Roads, and in Bulletins Nos. 105, 257, and 407, U. S. Department of Agriculture.

Experiment at Garden City.—This road was inspected December 9, 1916. The ruts and low places mentioned in the last report had been repaired by the addition of new material and by the liberal use of the road drag. The road had been resurfaced for a distance of 600 feet between station 6 and the bridge across the Arkansas River. There had been no rain since this work was done, and because of a lack of moisture the surface was not very well bonded. In general, this experiment was in a good condition.

Experiments at Bucklin.—This road was inspected December 8, 1916. Its condition, in general, was very poor. The surface was badly rutted and had worn very thin in places. From station 46 to the bridge it had been badly damaged from flood water of the Arkansas River in the spring of 1915. This section had been rebuilt and surfaced and was in good condition except that the surface was very poorly bonded. The summer had been exceptionally dry and very little improvement had been made by using the road drag in maintenance.

Experiment at Ford.—This road was inspected December 8, 1916, and was in good condition generally. The low places and ruts mentioned in the last report had been properly repaired. The surface was very smooth and well bonded.

These experimental sand-clay roads have led, either directly or indirectly, to the construction of many similar roads in that part of the country. According to statistics gathered by the Office of Public

Roads and Rural Engineering, United States Department of Agriculture, in 1914 Kansas alone had more than 750 miles of road surfaced with sand-clay, which was almost three-fourths of the total mileage of improved roads in the State. It seems, therefore, that these experiments have served their purpose entirely, and they will not be reported on again.

BOWLING GREEN, KY., 1907.

KENTUCKY ROCK ASPHALT.

The original report of this experiment was published in Circular No. 89 and reports of subsequent inspections in Circulars Nos. 90, 92, 94, 98, and 99, and Bulletins Nos. 105, 257, and 407 United States Department of Agriculture. The following report relates to the condition of the pavement on January 6, 1917. This work had not been repaired or cared for in any way since its construction. The failure of the surface was most marked in the west 150 feet. On the north side of this section the surface failed for one-third the width of the road and the remaining area was covered with holes. The next 150 feet had several large worn areas and numerous pot holes. The surface of the remaining portion still was intact and where the binder had not failed the surface was smooth and hard. Generally speaking, the condition of this experimental road would not warrant any repairs in the future.

RÉSUMÉ OF PREVIOUS REPORTS.

A series of experimental road sections were constructed in 1907, for the purpose of determining the fitness of Kentucky rock asphalt and crude Kentucky oil on binders in macadam construction and also to determine the comparative value of a residuum oil preparation and crude oil as dust preventives. The following table indicates the method of construction and shows the condition of experimental sections at the time of several inspections. The tabulation has been prepared from reports of inspections made by this office, published in Circulars Nos. 89, 90, 92, 94, 98, 99, and in Bulletins Nos. 105, 257, and 407, United States Department of Agriculture.

TABLE 71.—*Experiments at Bowling Green, Ky.*

Experiment No.	Length.	Description of original construction, 1907.	Condition January, 1909.	Condition May, 1909, after heavy rains.	Condition December 21, 1910.	Condition November 23, 1911.	Condition January 10, 1913.	Condition January 5, 1914.	Condition November 5, 1914.	Condition December 13, 1915.
	Feet.									
1	385	*Rock asphalt.*—Scarified gravel base, 4-inch limestone, loose, rolled once to smooth; 1½-inch fine crushed rock asphalt; finished by thorough rolling.	Road smooth, free from ruts, limestone showing in only two small places which were perfectly bonded; at one place shoulders had settled slightly.	Surface clean, smooth, and compact; no ruts; surface course of rock asphalt worn down in places to crushed stone, but stones were tightly bound.	(Light rains alternating with freezing weather for 10 days preceding.) Smooth and hard generally; eastern half shallow ruts about 2 feet from edges, indicating insecure shoulders; one small hole 100 feet from eastern end.	Surface hard, firm, fairly smooth, well bound; small hole mentioned in last report now about 1 foot in diameter.	Surface generally intact, smooth, and hard; hole at east end not yet repaired; three small worn places at 3, 25, and 45 feet, respectively, from west end; disintegrated asphalt; also three shallow depressions in crown at middle of section.	For 50 feet from west end north half badly worn and rock asphalt over half gone; south half in fair condition; 33 depressions in remainder of section, showing that disintegration has been quite rapid during the year.	No maintenance, and accumulation of dirt on surface. No great change in condition. In places practically all asphalt has disappeared.	No repairs; area of defects materially increased.
2	631	*Oil penetration.*—Gravel road; rather flat crown; application of heavy oil, mixture of residual oils; average 0.9 gallon per square yard; applied with gravity sprinkler.	Section had been covered with gravel, and no result was obtained from its use.							

TABLE 71.—*Experiments at Bowling Green, Ky.*—Continued.

Experiment No.	Length.	Description of original construction, 1907.	Condition January 1909.	Condition May, 1909, after heavy rains.	Condition December 21, 1910.	Condition November 23, 1911.	Condition January 10, 1913.	Condition January 5, 1914.	Condition November 5, 1914.	Condition December 13, 1915.
3	*Feet.* 3,312	*Crude oil on gravel.*—Same base as section 2. Application, crude oil. Average, 0.84 gallon per square yard.	Use of crude oil of only temporary effect. No trace of oil apparent. According to report, oil acted as a successful temporary dust preventive.							
4	1,089	*Crude oil on macadam.*—Macadam road on Telford base; crown slightly more than 1 inch per foot; good repair. Application, crude oil. Average, 0.52 gallon per square yard.	Same as experiment 3.							

ADDITIONAL COPIES
OF THIS PUBLICATION MAY BE PROCURED FROM
THE SUPERINTENDENT OF DOCUMENTS
GOVERNMENT PRINTING OFFICE
WASHINGTON, D. C.
AT
10 CENTS PER COPY
∇